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Feb. 1905

REPORT OF THE PROCEEDINGS

OF THE

Thirty-third Annual Convention

OF THE

AMERICAN RAILWAY
MASTER MECHANICS' ASSOCIATION

(INCORPORATED)

HELD AT

SARATOGA, N. Y.,

June 21, 22 and 23, 1900.

CHICAGO:
THE HENRY O. SHEPARD COMPANY,
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OFFICERS FOR 1899-1900.

INCLUDING THE CONVENTION OF 1899.

PRESIDENT:
J. H. McCONNELL,
Omaha, Neb.

FIRST VICE-PRESIDENT:
W. S. MORRIS,
Richmond, Va.

SECOND VICE-PRESIDENT:
A. M. WAITT,
New York City.

THIRD VICE-PRESIDENT:
J. N. BARR,
Baltimore, Md.

TREASURER:
G. W. WEST,
Middletown, N. Y.

SECRETARY:
J. W. TAYLOR,
Chicago, Ill.

OFFICERS FOR 1900-1901.

ELECTED AT CLOSE OF CONVENTION OF 1900.

PRESIDENT:
W. S. MORRIS,
Richmond, Va.

FIRST VICE-PRESIDENT:
A. M. WAITT,
New York City.

SECOND VICE-PRESIDENT:
J. N. BARR,
Baltimore, Md.

THIRD VICE-PRESIDENT:
G. W. WEST,
Middletown, N. Y.

TREASURER:
ANGUS SINCLAIR,
New York City.

SECRETARY:
J. W. TAYLOR,
Chicago, Ill.

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6.—*What Should be the Arrangement and Accessories of an Up-to-date Roundhouse?*

ROBERT QUAYLE, Chairman.
V. B. LANG.
D. VAN ALSTINE.

7.—*Maximum Monthly Mileage That Is Practicable and Advisable to Make; How Best to Make It, Both in Passenger and Freight Service.*

GEORGE F. WILSON, Chairman.
MORD ROBERTS.
T. H. SYMINGTON.

8.—*What Is the Most Approved Method for Unloading Locomotive Coal, Prior to Being Unloaded on the Tank?*

WILLIAM GARSTANG, Chairman.
T. S. LLOYD.
W. E. SYMONS.

9.—*Subjects.*

F. D. CASANAVE, Chairman.
S. M. VAUCLAIN.
A. J. PITKIN.

10.—*Advisability of This Association Joining the International Association for Testing Materials.*

S. M. VAUCLAIN, Chairman.
H. S. HAYWARD.
T. W. GENTRY.

11.—*Establishment of a Library in Connection with the Master Car Builders' Association.*

A. M. WAITT.

12.—*Index of Proceedings.*

F. A. DELANO, Chairman.
S. P. BUSH.
C. M. MENDENHALL.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them;

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car-building works.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. All members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

Sec. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

Sec. 5. Members of the Association who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members, except that of voting.

Sec. 6. Any member who, during the meetings of the Association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

Section 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, and a Secretary; and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

Section 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees—designating the chairman — and approve all bills against the Association for payment by the Treasurer.

Sec. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

Sec. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

Sec. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report.

SEC. 3. Three members shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of members or of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employes or the sons of other railroad employes for the Fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the families of members, preference shall be given to employes or the sons of employes, or the sons of deceased employes of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SECTION 1. The officers of the Association, except the Secretary as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the result.

SEC. 3. A Secretary from among the members of the Association shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by vote of the majority of the Executive Committee. He shall also act as Secretary of the Executive Committee.

ARTICLE IX.

AUDITING COMMITTEE.

SECTION 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a committee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report on any subject which a majority of the members present may approve.

ARTICLE X.

AMENDMENTS.

SECTION 1. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually on the third Tuesday in June.

HOURS OF SESSION.

II. The regular hours of session shall be from 9 o'clock A.M. to 2 o'clock P.M.

PLACE OF MEETING.

III. Places for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association, and the President, three Vice-Presidents and Secretary of the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon a place of meeting, the place receiving the largest number of votes to be selected.

QUORUM.

IV. At any regular meeting of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.
10. Reading of papers and discussion of questions propounded by members.
11. Routine and miscellaneous business.
12. Election of officers.
13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken.

NAMES AND ADDRESSES OF MEMBERS.

ACTIVE MEMBERS.

JOINED	NAME.	ROAD.	ADDRESS.
1896	Adams, T. E.	Great Northern	West Superior, Wis.
1888	Addis, J. W	Texas & Pacific	Marshall, Tex.
1895	Aikin, C. L.	Boston & Maine	Springfield, Mass.
1887	Aldcorn, Thos		New Durham, N. J.
1892	Allen, G. S.	Philadelphia & Read'g.	Tamaqua, Pa.
1894	Allin, Richard	Arkansas Midland	Helena, Ark.
1895	Amann, W. E		1536 St. Charles st., Alameda, Cal.
1892	Antz, Oscar	Lake Shore & Michigan Southern	Buffalo, N. Y.
1900	Appleyard, W. P	N. Y. N. H. & H	New Haven, Conn.
1887	Arp, W. C	Terre Haute & Indianapolis	Terre Haute, Ind.
1890	Atkinson, R	Canadian Pacific	Montreal, Que.
1896	Atterbury, W. W	Pennsylvania	Altoona, Pa.
1887	Augustus, W	Keokuk & Western	Centerville, Iowa.
1886	Austin, W. L.	Baldwin Loco. Works	Philadelphia, Pa.
1896	Babcock, C. M.	Texas & Pacific	Gouldsboro, La.
1898	Baker, C. F.	Boston Elevated	Boston, Mass.
1894	Balkam, S. T.		Calle Teatro No. 17, Monterey, N. L., Mexico.
1898	Barhydt, J. A	Buff. Roch. & Pitts	Rochester, N. Y.
1894	Barnes, Chas. H.	Boston & Albany	Springfield, Mass.
1888	Barnes, J. B	Wabash	Springfield, Ill.
1877	Barnett, J. Davis		Stratford, Ont.
1890	Barnum, M. K	Union Pacific	Omaha, Neb.
1890	Barr, J. N	Baltimore & Ohio	Baltimore, Md.
1899	Barrington, Edw	Vera Cruz & Pacific.	City of Mexico, Mex.
1895	Bartlett, Henry.	Boston & Maine.	Boston, Mass.
1899	Bates, F. L	Southern Pacific.	San Francisco, Cal.
1895	Bay, J. P.	K. C. Southern	Shreveport, La.
1885	Bean, John	Clev. Canton & South'n.	Canton, Ohio.
1889	Bean, S. L	Northern Pacific.	Brainerd, Minn.
1892	Beattie, A. L.	New Zealand Gov't.	Wellington, N. Z.
1899	Beauclerk, T.	Central Argentino.	Rosario de Santa Fe, Arg. Rep., S. A.
1894	Beaumont, J. G	Southern R'ys of Peru.	Arequipa, Peru.
1892	Bechhold, H. G.	Cleveland Frog & Crossing Co.	Cleveland, Ohio.
1885	Beckert, Andrew	Louisville & Nashville.	Decatur, Ala.
1896	Belcher, A. W	Ulster & Delaware	Rondout, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1892	Beltz, A. J	Del. Sus. & Schuylkill	Drifton, Pa.
1892	Benson, A. E	Ulster & Delaware	Rondout, N. Y.
1900	Bentley, H. J	Chgo. & North-West'n	Clinton, Iowa.
1891	Berry, J. H	C. N. O. & T. P	Chattanooga, Tenn.
1900	Best, W. N	Los Angeles Terminal	Los Angeles, Cal.
1892	Billingham, Jos	Baltimore & Ohio	Cumberland, Md.
1879	Bisset, John	Atlantic Coast Line	Wilmington, N. C.
1899	Bissett, J. R	Atlantic Coast Line	South Rocky Mountain, N. C.
1872	Blackall, R. C	Delaware & Hudson	Albany, N. Y.
1883	Blackwell, Chas		1010 Grand ave., Toledo, Ohio.
1898	Bocquet, H. C	Leopoldina R'y	Rio de Janeiro, Brazil, S. A.
1899	Boldridge, B. M	So. R'y in Kentucky	Louisville, Ky.
1869	Bond, I	Erie	Hornellsville, N. Y.
1893	Boon, J. M		5117 Madison ave., Chicago, Ill.
1899	Bonner, John	Cal. Northwestern	Tiburon, Cal.
1897	Bowles, C. K	Farmville & Powhatan	Chester, Va.
1895	Bradeen, A. A	L. S. & M. S	Cleveland, Ohio.
1895	Bradeen, J. O	L. S. & M. S	Norwalk, Ohio.
1888	Bradley, W. F	Ann Arbor	Durand, Mich.
1894	Branch, Geo. E	Brooklyn Wharf & Warehouse Terminal	Brooklyn, N. Y.
1896	Brangs, P. H		160 Broadway, New York City.
1893	Brantner, Z. T	Baltimore & Ohio	Brunswick, Md.
1900	Brassell, J. K	Cal. Northwestern	Tiburon, Cal.
1892	Brehm, W. H	Mo. Kan. & Texas	Parsons, Kan.
1897	Briggs, D. D	Louisville & Nashville	New Orleans, La.
1879	Briggs, R. H	K. C. M. & B	Memphis, Tenn.
1898	Bronner, E. D	Michigan Central	Detroit, Mich.
1887	Brooke, Geo. D	Iowa Central	Marshalltown, Iowa.
1890	Brown, Angus	Wisconsin Central	Waukesha, Wis.
1892	Brown, David	Del. Lack. & Western	Scranton, Pa.
1891	Brown, J. L		Water Works, Allegheny, Pa.
1896	Brown, M. D	Mo. Kan. & Texas	New Franklin, Mo.
1891	Brown, W. A	Buffa. & Susquehanna	Galeton, Pa.
1895	Browne, T. R	Pennsylvania	Altoona, Pa.
1882	Brownell, F. G		Muncie st., Muncie, Ind.
1897	Bruce, Geo. A	Great Northern	St. Paul, Minn.
1890	Bruck, Henry T	Cumb. & Penna	Mt. Savage, Md.
1882	Bryan, H. S	Duluth & Iron Range	Two Harbors, Minn.
1900	Bryan, L. H	Duluth & Iron Range	Two Harbors, Minn.
1900	Buchanan, A., Jr	Delaware & Hudson	Green Island, N. Y.
1887	Buchanan, Wm		Larchmont, N. Y.
1896	Buck, Geo. W	Great Northern	St. Paul, Minn.
1893	Buckalew, J. H	Mem. & Charleston	Memphis, Tenn.
1893	Bush, S. P	Chgo. Mil. & St. Paul	Milwaukee, Wis.
1870	Bushnell, R. W	B. C. R. & N	Cedar Rapids, Iowa.
1893	Butcher, Geo. W	San Antonio & A. Pass	San Antonio, Tex.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Butler, L. M	N. Y. New Haven & Hartford	Valley Falls, R. I.
1891	Campbell, John D		657 Quincy ave., Scranton, Pa.
1900	Canfield, L. T	Del. Lack. & Western	Scranton, Pa.
1896	Cannon, T. E	Great Northern	Barnesville, Minn.
1900	Carney, J. A	Chgo. Bur. & Quincy	Beardstown, Ill.
1896	Carr, Jas	St. L. I. M. & S	Van Buren, Ark.
1885	Carson, M. T	Mobile & Ohio	Mobile, Ala.
1889	Casanave, F. D	Pennsylvania	Altoona, Pa.
1890	Casey, J. J	Haskell & Barker	Michigan City, Ind.
1892	Chamberlin, E		757 Prospect ave., Buffalo, N. Y.
1893	Chambers, Jno. S	Cent. R. R. of N. J	Elizabethport, N. J.
1878	Chapman, T. L	Southern R'y	Washington, D. C.
1896	Chase, F. A	Hannibal & St. Joseph	St. Joseph, Mo.
1893	Childs, H. A	Erie	Jersey City, N. J.
1898	Christopher, J	Toronto, Hamilton & Buffalo	Hamilton, Ont., Can.
1899	Christie, W. K	Pere Marquette	Saginaw, Mich.
1896	Chubb, Thos. L	Buenos Ayres W	La Plata, Ar. Rep., S. A.
1899	Clark, F. H	Chicago, Burlington & Quincy	Chicago, Ill.
1886	Clark, Isaac W		Fayetteville, N. C.
1897	Clarke, Owen	Texas & Pacific	Marshall, Tex.
1893	Cleaver, F. C	L. E. & St. L. Con	Princeton, Ind.
1892	Clifford, C. J	New York Central & Hudson River	Albany, N. Y.
1887	Clifford, J. G		Tenth and Kentucky sts., Louisville, Ky.
1887	Cloud, John W		82 York Road, King's Cross, London, Eng.
1896	Coale, J. M	Northern Central	Baltimore, Md.
1895	Cockfield, Jos	Chicago & North-Western	Clinton, Iowa.
1891	Cockfield, Wm	Mexican Central	San Luis Potosi, Mex.
1896	Cole, F. J		Rogers Locomotive Works, Paterson, N. J.
1891	Collinson, Jas	Gulf, Colo. & Santa Fe	Galveston, Tex.
1890	Conolly, J. J	Dul. So. Shore & Atlantic	Marquette, Mich.
1899	Cook, A. B	Central Argentino	Rosario de Santa Fe, Arg. Rep., S. A.
1879	Cook, John S	Georgia	Augusta, Ga.
1879	Cooke, Allen		Danville, Ill.
1898	Cooper, C. J	Toledo & Ohio Central	Kenton, Ohio.
1898	Cooper, D. S	Rich. Fred. & Potomac	Richmond, Va.
1876	Cory, C. H	Cin. Ham. & Dayton	Lima, Ohio.
1900	Courtney, D. C	West Va. Central & Pittsburg	Elkins, W. Va.
1900	Crawford, D. F	Pennsylvania Lines	Ft. Wayne, Ind.
1892	Crawford, S. B	Baltimore & Ohio	Parkersburg, W. Va.
1885	Cromwell, A. J		1411 Hollins st., Baltimore, Md.
1893	Cross, W	Canadian Pacific	Winnipeg, Man.
1896	Cullinan, J	Col. Sand. & Hocking	Columbus, Ohio.
1899	Cumback, R. O	Cent. R. R. of N. J	Elizabethport, N. J.
1899	Cunningham, Jas	Choc., Okla. & Gulf	Shawnee, O. T.
1900	Curley, M. S	Illinois Central	Memphis, Tenn.

JOINED.	NAME.	ROAD.	ADDRESS.
1872	Cushing, G. W		Evanston, Ill.
1888	Dallas, Wilber C	Galena Oil Co	Franklin, Pa.
1890	Davies, J. M		56 Broad st., Plattsburgh, N. Y.
1899	Davis, Chas. H	Barclay; State Line & Sullivan	New York City.
1892	Davis, Ed. E	N. Y. Cent. & Hudson River	New York, N. Y.
1899	Davis, M. R	Portland & Rum. Falls	Rumford Falls, Me.
1893	Davis, Wm. J	Pitts & Western	Foxbury, Pa.
1900	Davisson, F. E	Santa Fe, Pres. & Phœnix	Prescott, Ari.
1897	Dawson, E		Osceola, Iowa.
1891	Deems, J. F	Chgo. Bur. & Quincy	West Burlington, Iowa.
1896	De Gress, C	Mex. Nat. Construc. Co.	Colima, Mex
1897	De Haven, C. A		Wichita, Kan.
1897	Delaney, C. A	Supt. Dickson Loco. Works	Scranton, Pa.
1895	Delaney, H	Phila. & Reading	Philadelphia, Pa.
1899	Delano, F. A	Chgo. Bur. & Quincy	Chicago, Ill.
1900	Demarest, T. W	Penna. Lines	Columbus, Ohio.
1896	Dickerson, S. K	Norfolk & Western	Roanoke, Va.
1887	Dickson, G. L	Dickson Loco. Works	Scranton, Pa.
1894	Dixon, W. F	Sormovo Loco. Works	Nijni-Novgorod, Russia.
1897	Doebler, C. H	Wabash	Springfield, Ill.
1898	Dolan, S. M	Wiggins Ferry Co	East St. Louis, Ill.
1896	Donahue, Geo	Erie	Cleveland, Ohio.
1880	Dotterer, D. H		45 Wellington ave., Rochester, N. Y.
1893	Dow, Jas. M		Kenton, Ohio.
1890	Downing, T		Station E, Minneapolis, Minn.
1899	Downing, T. M	Detroit & Lima Nor.	Tecumseh, Mich.
1893	Drury, Michael J	Atch. Top. & Santa Fe	Arkansas City, Kan.
1900	Dunn, A. J	Atl. Knoxville & Northern	Blue Ridge, Ga.
1896	Dunn, J. F	Oregon Short Line	Salt Lake City, Utah.
1900	Edwards, J. A	Rio Grande Southern	Ridgway, Colo.
1899	Egan, J. A	Mexican Southern	Oaxaca, Mex.
1900	Elden, Edw	Fitchburg	Charlestown, Mass.
1869	Elliott, Henry		East St. Louis, Ill.
1899	Ellis, H. D	Anglo-Chilian Nitrate & R'y Co.	Tocapilla, Chili.
1895	Ellis, John	Maine Central	Waterville, Me.
1893	Ellis, John J	C. St. P. M. & O	St. Paul, Minn.
1893	English, Richard	Rio Grande Western	Helper, Utah.
1881	Ennis, W. C		543 Broadway, Paterson, N. J.
1898	Erskine, A. S	Wiscasset & Quebec	Wiscasset, Me.
1892	Esson, R. C	Southern Pacific	Newark, Cal.
1898	Ettinger, R. L	C. C. C. & St. L	Indianapolis, Ind.
1900	Ewing, J. J	Ches. & Ohio	Richmond, Va.
1900	Feeley, T. M	Southern	Birmingham, Ala.
1885	Ferguson, G. A		Lakeport, N. H.

JOINED.	NAME.	ROAD.	ADDRESS.
1896	Fisher, G. P	Texas Midland	Terrell, Texas.
1892	Fitzmorris, Jas	Chicago Junction	Union Stock Yards, Chicago, Ill.
1895	Foller, P. P	W. N. Y. & Pa	Oil City, Pa.
1896	Foque, T. A	M. St. P. & S. Ste. M.	Minneapolis, Minn.
1900	Forsyth, A.	Chgo. Bur. & Quincy	Aurora, Ill.
1888	Forsyth, Wm		Aurora, Ill.
1875	Foster, W. A.	Fall Brook R'y Co.	Corning, N. Y.
1890	Foulk, John	Litch. Car. & Western	Litchfield, Ill.
1877	Fowle, I. W.	Colo. & Southern	Trinidad, Colo.
1891	French, R. E	Southern Pacific	Kern, Cal.
1898	Frey, N	Chgo. Bur. & Northern	La Crosse, Wis.
1890	Fuller, C. E.	Erie	Susquehanna, Pa.
1872	Fuller, Wm		213 Kennard st., Cleveland, Ohio.
1893	Gage, George W	St. Louis Southwestern	Pine Bluff, Ark.
1897	Gaines, F. F	Lehigh Valley	South Easton, Pa.
1898	Galbraith, H. D	St. Louis Southwestern	Texarkana, Ark.
1891	Galbraith, R. M.		Pine Bluff, Ark.
1897	Gardner, A	C. & C. V.	Cooperstown, N. Y.
1893	Garrick, J. R	Gulf, Houston & San. Anto.	El Paso, Tex.
1892	Garrison, P. E.	Fonda, Johnstown & Gloversville	Gloversville, N. Y.
1887	Garstang, Wm	C. C. C. & St. L	Indianapolis, Ind.
1900	Gaskins, W. B	Pecos Valley & Northeastern	Roswell, N. M.
1886	Gentry, T. W	Richmond Loco. Works	Richmond, Va.
1899	Gibb, T. W.		Trinidad, Colo.
1888	Gibbs, A. W	Pennsylvania	Altoona, Pa.
1890	Gibbs, George	Baldwin Loco. Works	Philadelphia.
1896	Gill, Jno	C. R. I. & P	Trenton, Mo.
1891	Gillis, H. A	Richmond Loco. Works	Richmond, Va.
1883	Gilmore, W. L	Lake Shore & Mich. Southern	Elkhart, Ind.
1893	Gilmour, George	N. Y. Telephone Co.	15 Dey st., New York.
1890	Givin, F. A.	Pitts. Shawmut & Northern	St. Mary's, Pa.
1897	Glaser, J	Cleveland & Marietta	Cambridge, Ohio.
1891	Glass, John C	Allegheny Valley	Verona, Pa.
1880	Gordon, H. D		71 John st., New York.
1879	Gordon, James T	Concord	Concord, N. H.
1900	Gould, J. E.	C. N. O. & T. P	Chattanooga, Tenn.
1899	Gould, R.	Buenos Ayres Great Southern	Buenos Ayres, Arg. Rep., S. A.
1892	Graham, Charles, Jr.	D. L. & W	Kingston, Pa.
1894	Graham, J. A	Clev. Lorain & W	Lorain, Ohio.
1894	Grant, A. S.	H. E. & W. T.	Houston, Tex.
1889	Greatsinger, J. I	D. & I. Range	Duluth, Minn.
1897	Greaven, Luis	Interoceanic	Puebla, Mex.
1895	Green, Wilbur	San Anto. & Aransas Pass	Yoakum, Tex.
1896	Greenwood, Alfred W.	East Broad Top	Rockhill Furnace, Pa.
1885	Griffith, Fred B.		Buffalo, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1893	Gross, R. J.		Brooks Loco. Works, Dunkirk, N. Y.
1896	Groves, J. R		Springfield, Mo.
1900	Gurry, Geo		International Power Co., Providence, R. I.
1880	Hackney, Clem.		Joliet, Ill.
1875	Haggett, J. C.		Dunkirk, N. Y.
1893	Hainen, J.	Erie	Port Jervis, N. Y.
1898	Hair, John.	Balto. & Ohio S.-W.	Washington, Ind.
1896	Hall, J. W		Ft. Worth, Tex.
1891	Hancock, Geo. A.	St. Louis & San Fran.	Springfield, Mo.
1893	Hancock, Wm. S	Santa Fe Pacific	Needles, Cal.
1896	Hanglin, J. A.	Hot Springs	Malvern, Ark.
1899	Hansgen, J. A.	Findlay, Ft.W. & West.	Findlay, Ohio.
1893	Hardie, Jas.		Hardie & Co., Valparaiso, Chili.
1900	Harrington, W	Fitchburg	Mechanicsville, N. Y.
1896	Harrison, Jno.	San Paulo	San Paulo, Brazil, S. A.
1898	Harrison, F. J.	Buffa., Roch. & Pitts.	Rochester, N. Y.
1889	Haskell, B.	Pere Marquette	Saginaw, Mich.
1888	Hassman, Wm.	Central Vermont	St. Albans, Vt.
1875	Hatswell, T. J.	Pere Marquette	Saginaw, E. S., Mich.
1897	Hatswell, T. J., Jr.	Pere Marquette	Saginaw, E. S., Mich.
1900	Hawkins, B. H.	Denver & Rio Grande.	Denver, Colo.
1895	Hawksworth, D.	Burl. & Mo. River	Plattsmouth, Neb.
1899	Hawthorne, J.	Lehigh Valley	Sayre, Pa.
1898	Hayden, J. C.	Mexican National	Acambara, Mex.
1896	Hayward, H. S.	Pennsylvania	Jersey City, N. J.
1891	Hedley, F.	Lake Street Elevated	Chicago, Ill.
1896	Heers, L. B.	Pitts., Shaw. & Nor.	Angelica, N. Y.
1887	Heintzleman, T. W.	Southern Pacific	Sacramento, Cal.
1888	Hemphill, W. J.		Springfield, Ill.
1886	Hendee, A.	Panama	Colon, U. S. C.
1892	Henderson, G. R.	Chgo. & North-West'n.	Chicago, Ill.
1897	Hennessey, T. J.	Michigan Central	Jackson, Mich.
1897	Hepburn, G. W.	Ches. & Ohio	Hinton, W. Va.
1898	Herbert, R. L.	G. H. & S. A.	El Paso, Tex.
1892	Herr, Edwin M.		136 Ditteridge st., Pittsburg, Pa.
1871	Hewitt, John.		1323 South Jefferson Street, St. Louis, Mo.
1895	Hibbard, H. Wade.	Cornell University	Ithaca, N. Y.
1883	Hickey, John	Rio Grande Western	Salt Lake City, Utah.
1890	Higgins, S.	Lehigh Valley	S. Bethlehem, Pa.
1887	Hill, Jas. W.	P. & Pekin Union	Peoria, Ill.
1892	Hill, Rufus	Pennsylvania	Pavonia, N. J.
1897	Hinchey, Jas.	Central Vermont	New London, Conn.
1892	Hinkley, A. C.		St. Joseph, Mo.
1900	Hodgkins, W. W	Boston & Maine	Worcester, Mass.
1883	Hoffecker, W. L.		Elizabethport, N. J.

JOINED.	NAME.	ROAD.	ADDRESS.
1899	Hoffman, R. F.		*Railroad Gazette*, New York City.
1896	Hogsett, C. E.		Montezuma Copper Co., Bisbee, Arizona.
1892	Holland, W. D.		927 O'Farrell Street, San Francisco, Cal.
1885	Holman, W. L.	Pennsylvania	Renova, Pa.
1890	Homer, John C.	Cin., P. & Virginia	Portsmouth, Ohio.
1900	Hone, A. C.	Evans. & Terre Haute	Evansville, Ill.
1896	Hopgood, Jno.	Argentine Gt. West.,	Mendoza, Argentine Rep., S. A.
1896	Horrigan, Jno.	E. J. & E.	Joliet, Ill.
1892	Howard, C. H.		Union Trust Bldg., St. Louis, Mo.
1896	Howard, Jno.	West Shore	New Durham, N. J.
1890	Hudson, E. E.	C. C. C. & St. L	Bellefontaine, Ohio.
1899	Hudson, H. G	C. C. C. & St. L	Mt. Carmel, Ill.
1892	Hudson, W. H	Southern	Spencer, N. C.
1890	Hufsmith, F	I. & G. N	Palestine, Tex.
1890	Humphrey, A. L	Colorado Midland	Colorado City, Colo.
1896	Hyndman, F. T	Pitts. & Western R'y.	Allegheny, Pa.
1900	Impett, J. J.	Cent. R'y of Peru	Lima, Peru, S. A.
1896	Inge, T. S	Southern	Columbia, S. C.
1900	Irwin, J. E	Toledo & Ohio Cent	Columbus, Ohio.
1888	Jackson, O. H	Belt Line	Indianapolis, Ind.
1899	James, E. T	Lehigh Valley	Wilkesbarre, Pa.
1896	James, Geo	N. Y. C. & St. L	Stony Island, Ill.
1900	Jennings, Thos.	Fitchburg	Keene, N. H.
1890	Jennings, Wm.	Mexican International	Ciudad Porfirio, Diaz, Mex.
1893	Jerome, E. W		557 Second st., Albany, N. Y.
1896	Johnson, A. B.		Baldwin Loco. Works, Philadelphia, Pa.
1878	Johnson, J. B	Arkansas Midland	Helena, Ark.
1887	Johnson, L. R	Canadian Pacific.	Vancouver, B. C.
1898	Johnson, R. H	St. Louis Southwestern	Pine Bluff, Ark.
1887	Johnstone, F. W	Mexican Central	City of Mexico, Mex.
1888	Joughins, G. R.	Intercolonial	Moncton, N. B., Can.
1896	Justice, D. J	Atlantic Coast Line	Florence, S. C.
1890	Kalbaugh, I. N	Baltimore & Ohio	Newark, Ohio.
1892	Keegan, Jas. E.	G. R. & Ind	Grand Rapids, Mich.
1890	Keith, J. M.	W. R'y of Gautemala	San Filipe, Gautemala, C. A.
1896	Kells, Willard	Erie	Meadville, Pa.
1896	Kelly, Wm	Great Northern	Everett, Wash.
1894	Kennedy, Jas	Jamaica	Kingston, Jamaica.
1893	Kenney, Geo. W	Rutland	Rutland, Vt.
1890	Killen, W. E	C. P. & St. L St. L. C. & St. P Alton Terminal	Jacksonville, Ill.

JOINED.	NAME.	ROAD.	ADDRESS.
1900	Kilpatrick, R. F	Dela. Lack. & West'n	Kingsland, N. J.
1898	King, D. M	Raleigh & Gaston	Raleigh, N. C.
1892	Kirk, John		Pueblo, Colo.
1892	Kistler, Lewis		Syracuse, N. Y.
1900	Knapp, E. W	Mich. & Pacific	Zitamaro, Mexico.
1890	Knapp, G	Humeston & Shenandoah,	Shenandoah, Iowa.
1899	Knapp, L. I	Lehigh Valley	Buffalo, N. Y.
1899	Kummer, W. M	Au Sable & Nor. West.	Au Sable, Mich.
1899	Lachlan, Wm	E de F. Porto Alegre e Uruguayana,	Santa Maria E Rio Grande, Brazil, S. A.
1898	Laing, W	Texas & Pacific	Texarkana, Tex.
1900	Laird, Alex	Ohio & Little Kanawha	Zanesville, Ohio.
1898	Lake, E. M	Gulf & Ship Island	Gulfport, Miss.
1894	Lang, V. B	Chicago & Alton	Bloomington, Ill.
1899	Langston, C. J	Miss. River, Hamburg & Western,	Hamburg, Ark.
1888	Lape, C. F	So. Cal	San Bernardino, Cal.
1895	Lauer, F. G		Du Bois, Pa.
1889	Lavery, W	Erie	New York, N. Y.
1891	Lawler, F. M	C. C. C. & St. L	Brightwood, Ind.
1891	Lawes, T. A	C. & E. I	Danville, Ill.
1896	Lawrence, J. L	Cumb. Valley	Chambersburg, Pa.
1890	Leach, H. L		Room 45, Mason Bldg., Boston, Mass.
1892	Lee, C. W	Southern	Greensboro, N. C.
1883	Leeds, Pulaski	Louisville & Nashville	Louisville, Ky.
1888	Leigh, F. J	Can. Loco. Works,	Kingston, Ont.
1890	Leonard, A. G	Chicago Junction	Chicago, Ill.
1873	Lewis, W. H	D. L. & W	Hoboken, N. J.
1876	Lewis, W. H	Norfolk & Western	Roanoke, Va.
1896	Lindoff, Geo	Montana Union	Anaconda, Mont.
1896	Linstrom, Chas	Yazoo & Miss. Valley	Vicksburg, Miss.
1890	Lloyd, T. S	Dela., Lack. & West	Scranton, Pa.
1890	Logan, P. A	Can. Eastern	Gibson, N. B.
1895	Lonergan, P. T	N. Y. C. & H. R	Oswego, N. Y.
1868	Losey, Jacob	Louisville Steam Forge Co.,	Louisville, Ky.
1899	Lovell, Alfred	Northern Pacific	St. Paul, Minn.
1900	Lowell, W. W	Han. & St. Joseph	Brookfield, Mo.
1897	Lucas, W. O	Central Argentine	Rosario, Arg. Rep., S. A.
1894	Lyon, Tracy	Chic. Gt. Western	St. Paul, Minn.
1885	Lythgoe, Joseph	International Power Co.,	Providence, R. I.
1887	Macbeth, Jas	N. Y. Central	Buffalo, N. Y.
1892	Macdonald, Aug. V	New Zealand R'ys	Newmarket, Auckland, N. Z.
1890	Macfarlane, T. W		Assumption, Ill.
1899	Machesney, A. G	Baldwin Loco. Works,	Philadelphia, Pa.
1876	Mackenzie, John	N. Y. C. & St. L	Cleveland, Ohio.

JOINED.	NAME.	ROAD.	ADDRESS.
1892	Mackinnon, Geo. S	Canadian Pacific	Toronto Junction, Ont.
1896	Maher, P	Ind., Ill. & Iowa	Kankakee, Ill.
1896	Mahl, F. W	So. Pac	Sacramento, Cal.
1899	Malone, I. M	Honduras	Puerto Cortez, Spanish Honduras.
1895	Mallinson, E. P		Malden, Mass.
1894	Manchester, A. E	C. M. & St. P	Milwaukee, Wis.
1893	Manning, J. H	Union Pacific	Cheyenne, Wyo.
1898	Marchbanks, James	Wellington & Manawatu,	Wellington, N. Z.
1896	Marden, J. W	Fitchburg	Boston, Mass.
1897	Marshall, B. F	Clev., Ak. & Columbus	Mt. Vernon, Ohio.
1890	Marshall, E. S	Manager, Western R'y Equipment Co.,	St. Louis, Mo.
1891	Marshall, W. H	Lake Shore & Mich. So.	Cleveland, Ohio.
1888	Maver, A. A	Grand Trunk	Stratford, Ont.
1891	McConnell, J. H	Union Pacific	Omaha, Neb.
1896	McCormick, A	Rock Island & Peoria	Peoria, Ill.
1892	McCuen, J. P	C. N. O. & T. P	Ludlow, Ky.
1891	McDonough, James	Gulf. Colo. & S. F	Galveston, Tex.
1892	McDuff, Allan	B. C. R. & N	Cedar Rapids, Iowa.
1893	McElvaney, C. T		American Cotton Co., Dennison, Tex.
1890	McIntosh, Wm	Central R. R. of N. J.	Jersey City, N. J.
1893	McKee, G. S	Wabash	Ft. Wayne, Ind.
1896	McLean, W. J	Bell. Bay & Brit. Col.	New Whatcom, Wash.
1894	McMasters, Chas. J	Benn. & Rutland	Rutland, Vt.
1896	McNabb, T	Gt. Falls & Canada	Lethbridge, Alberta, Can.
1890	McNaughton, Jas		Brooks Loco. Works, Dunkirk, N. Y.
1899	Meagher, W. A	G. B. & K. C	Beaumont, Tex.
1888	Medway, John		3995 Drexel Boul., Chicago, Ill.
1895	Mellin, C. J		Richmond Loco. Works, Richmond, Va.
1900	Mendenhall, C. M	Chicago & Alton	Bloomington, Ill.
1892	Mertsheimer, F	Kansas City Southern	Kansas City, Mo.
1887	Michael, J. B	Southern	Knoxville, Tenn.
1883	Middleton, Harvey		8 Read st., Baltimore, Md.
1885	Millen, Thos	Metropolitan Street R'y,	106 W. 51st st., New York.
1889	Miller, E. A	N. Y. C. & St. L	Conneaut, Ohio.
1890	Miller, Geo. A	Florida East Coast	St. Augustine, Fla.
1896	Miller, G. W	Erie	Elmira, N. Y.
1898	Miller, Robt		Detroit, Mich.
1893	Minshull, P. H	N. Y. O. & W	Middletown, N. Y.
1892	Minto, H. M	Louisville & Nashville	Mobile, Ala.
1888	Minton, A. B	Mobile & Ohio	Murphysboro, Ill.
1892	Mitchell, Alva	A. T. & S. F	Chanute, Kan.
1870	Mitchell, A	Lehigh Valley	Wilkesbarre, Pa.
1892	Mitchell, A. E	Erie	New York City.
1898	Moler, A. L		Baldwin Loco. Works, Philadelphia, Pa.
1890	Monkhouse, H	Chgo. Indpls. & Louisville,	Lafayette, Ind.
1884	Montgomery, Wm	Cent. of N. J	Lakehurst, N. J.

JOINED.	NAME.	ROAD.	ADDRESS.
1900	Morton, G. C	Natl. Tehuantepec	Coatzacoalcos, V. C., Mex.
1890	Moore, J. H	Erie	Buffalo, N. Y.
1895	Moraga, Anselmo	Chilian State	Santiago, Chili.
1896	Moran, Robt	Louisville & Nashville	Nashville, Tenn.
1887	Morris, W. S	Ches. & Ohio	Richmond, Va.
1898	Morrison, J. F	South Side Elevated	Chicago, Ill.
1890	Morse, F. W	Grand Trunk	Montreal, Can.
1899	Muhlfeld, J. E	Grand Trunk	Port Huron, Mich.
1890	Murphy, P. H	Murphy Car Roof Co.,	East St. Louis, Ill.
1894	Nettleton, W. A	K. C. Ft. Scott & Mem.	Kansas City, Mo.
1898	Neubert, G. T	Atch. Topeka & S. F	Arkansas City, Kan.
1892	Neuffer, John G	B. & O. S.-W	Cincinnati, Ohio.
1898	Newell, T. W		Blue Ridge, Ga.
1896	Neward, F. H	Pontiac, Ox. & North'n.	Pontiac, Mich.
1890	Nicholls, J. Mayne	Nitrate R'ys	Iquique, Chili.
1875	Noble, L. C	A. French Spring Co.,	1414 Fisher Bldg., Chicago.
1899	Nolan, J. P	Southern Pacific	Algiers, La.
1896	Norsworthy, N. W	Norfolk & Western	Crewe, Va.
1896	Nuttall, W. H	Manistee & N. East'n	Manistee, Mich.
1890	O'Brien, John	Rich. & Petersburg	Manchester, Va.
1890	O'Herin, Wm	Mo., Kan. & Tex	Parsons, Kan.
1895	O'Leary, D	Seattle & International	Seattle, Wash.
1895	Orland, W. P	C. C. C. & St. L	Mattoon, Ill.
1897	Osborne, H	Canadian Pacific	Montreal, Can.
1897	Owens, W. H	Southern	Manchester, Va.
1891	Pattee, J. O	Missouri Pacific	St. Louis, Mo.
1879	Patterson, J. S	Galena Oil Co.,	Cincinnati, Ohio.
1885	Paxson, L. B	Phila. & Reading	Reading, Pa.
1891	Paxton, Thos	A. T. & S. F	Ft. Madison, Iowa.
1899	Pearse, H	Buen. Ayres & Rosario	Campana, Arg. Rep., S. A.
1887	Peck, Peter H	C. & W. I. and Belt	Chicago, Ill.
1899	Pennington, J. H	Dela., Susq. & Schuyl.	Drifton, Pa.
1897	Peyton, H. T	A. T. & S. F.	Chanute, N. M.
1897	Pflager, H. M	Pullman Palace Car Co.,	Chicago, Ill.
1878	Pilsbury, Amos	Maine Central	Portland, Me.
1885	Pitkin, A. J	Schenectady Loco. Works,	Schenectady, N. Y.
1874	Place, T. W	Illinois Central	Waterloo, Iowa.
1900	Plank, P. D	Louis., Hend. & St. L.	Cloverport, Ky.
1881	Player, John	A. T. & S. F	Topeka, Kan.
1897	Pollitt, Harry	Great Central	Fernlea, Altricham, Cheshire, Eng.
1900	Post, W. F	Gulf & Ship Island	Gulfport, Miss.
1893	Potter, G. L	Penna. Lines	Pittsburg, Pa.
1897	Potton, J	Texas & Pacific	Big Springs, Tex.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Prescott, C. H.	Spokane Falls & Nor.	Spokane, Wash.
1900	Prince, S. F., Jr.	Phila. & Reading	Reading, Pa.
1890	Purves, T. B., Jr.	Boston & Albany	Springfield, Mass.
1888	Quayle, Robert	Chgo. & North-West'n.	Chicago, Ill.
1895	Quereau, C. H.	Denver & Rio Grande	Denver, Colo.
1888	Quinn, John A.	Ches. & Ohio	Clifton Forge, Va.
1896	Rainsford, Henry J.	Montana Union	Anaconda, Mont.
1890	Randolph, L. S.	Virginia Polytechnic Institute	Blacksburg, Va.
1891	Rearden, Frank		St. Louis, Mo.
1895	Redding, M. J.		Stamps, Ark.
1888	Reed, W. T.	Seaboard Air Line	Portsmouth, Va.
1890	Reid, M. M.	Southern	Lawrenceville, Va.
1883	Renshaw, W.	Illinois Central	Chicago, Ill.
1892	Rettew, C. E.	D. & H. C.	Carbondale, Pa.
1896	Reynolds, O. H.	Dickson Loco. Works	Scranton, Pa.
1887	Rhodes, G. W.	Burlington & Mo. Riv.	Lincoln, Neb.
1899	Rhodes, L. B.	Ga. Southern & Fla.	Macon, Ga.
1897	Rickert, Mason	C. C. C. & St. L.	Delaware, Ohio.
1894	Riley, George N.	National Tube Co.	McKeesport, Pa.
1899	Risteen, F. N.	Northern Pacific	Fargo, N. D.
1882	Roberts, E. M.		Sherman ave., Norwood, Cincinnati, Ohio.
1896	Roberts, J. W.		1124 Cornell ave., Indianapolis, Ind.
1891	Roberts, Mord.	Louisville & Nashville	Louisville, Ky.
1895	Robinson, Frank	Maine Central	Bangor, Me.
1898	Robinson, J. T.	Southern	Selma, Ala.
1896	Robkin, Charles	Little Rock & Mem.	Argenta, Ark.
1896	Rogers, M. J.	K. C. Belt	Kansas City, Mo.
1898	Romans, G. L.	Coast	Yarmouth, N. S., Canada.
1896	Rosing, W. H. V.	Illinois Central	Chicago, Ill.
1891	Rotheram, T. F.	New Zealand Govt.	Wellington, N. Z.
1895	Royal, C. B.	Flor. Cent. & Penin.	Jacksonville, Fla.
1898	Rumney, T.	Ogd. & Lake Champ.	Malone, N. Y.
1896	Rusch, Peter C.	Buffalo, Roch. & Pitts.	Bradford, Pa.
1893	Ryan, E.	Gal., Hous. & San An.	San Antonio, Tex.
1892	Ryan, Patrick	Louisville & Nashville	Russellville, Ky.
1891	Ryan, J. J.	Southern Pacific	Houston, Tex.
1891	Ryder, Henry	Housatonic	Falls Village, Conn.
1892	Sague, J. E.	Schenectady Loco. Works	Schenectady, N. Y.
1887	Sample, N. W.	Denver & Rio Grande	Denver, Colo.
1891	Sanborn, J. N.	Brainerd & No. Minn.	Brainerd, Minn.
1896	Sanderson, R. P. C.	A. T. & S. F.	Topeka, Kan.
1896	Sanford, J. W.	Pennsylvania	Jersey City, N. J.
1896	Santer, A.	Norfolk & Western	Lambert's Point, Va.

JOINED.	NAME.	ROAD.	ADDRESS.
1898	Schaefer, Hugo	Central New England	Hartford, Conn.
1874	Schlacks, Henry	Denver & Rio Grande	Denver, Colo.
1875	Sedgwick, E. V.		Galena Oil Co., Franklin, Pa.
1900	Seley, C. A.	Norfolk & Western	Roanoke, Va.
1869	Setchel, J. H.		Cuba, N. Y.
1868	Shaver, D. O.	Pennsylvania	Pittsburg, Pa.
1891	Sheer, Jas. M.		514 Seventh st., East St. Louis, Ill.
1899	Shepard, L. A.		Baldwin Loco. Works, Philadelphia, Pa.
1898	Shields, Alex.		Bedford, Ind.
1890	Shields, J. C.	Mineral Range	Hancock, Mich.
1898	Shone, G. H.	Denver & Rio Grande	Alamosa, Colo.
1883	Sinclair, Angus		95 Liberty st., New York City.
1892	Sinnott, B	Balto. & Ohio	Philadelphia, Pa.
1896	Skinner, Calvin	Toledo, St. L. & K. C.	Frankfort, Ind.
1889	Skinner, H. M. C.		88 Walnut st., Fall River, Mass.
1900	Slack, J. R.	Dela. & Hudson	Albany, N. Y.
1893	Slater, Frank	Chicago & N.-W.	Escanaba, Mich.
1889	Slater, John C.		Battle Mt., Nev.
1894	Slayton, C. E	Vir. & South-Western	Bristol, Tenn.
1889	Small, H. J.	Southern Pacific	Sacramento, Cal.
1900	Smith, D. A.	Boston & Maine	E. Somerville, Mass.
1893	Smith, F. B.	N. Y. N. H. & H.	New Haven, Conn.
1896	Smith, F. C.	Fitchburg	Keene, N. H.
1900	Smith, F. J.	B. & O. S.-W.	Chillicothe, Ohio.
1890	Smith, Geo. W.	Santa Fe Pacific	Albuquerque, N. M.
1894	Smith, H. C.		117A North Olive st., Los Angeles, Cal.
1892	Smith, John L.	Buffalo, Roch. & Pitts.	Du Bois, Pa.
1900	Smith, L. L.	Chgo. Gt. Western	Oelwein, Iowa.
1899	Smith, R. D	Chgo., Bur. & Quincy	Chicago, Ill.
1891	Smith, Wm.	Duluth, Missabe & Nor.	Duluth, Minn.
1869	Smith, W. T.	Chesapeake & Ohio	Covington, Ky.
1891	Soule, R. H.		71 Broadway, New York City.
1899	Spillard, L. H.	Santa Marta	Santa Marta, Col., S. A.
1897	Spragge, Jos. R	Can. Pacific	McAdam Junct., N. B.
1868	Sprague, H. N.		Jamestown, N. Y.
1895	Sprigg, Z. T.	Union Pacific	Denver, Colo.
1898	Stansbury, C. M.		Lafayette, Ind.
1894	Steele, S. A.	W. Va. & Pitts.	Weston, W. Va.
1899	Stevens, F. H.		Brooks Loco. Works, Dunkirk, N. Y.
1874	Stevens, Geo. W.		Elyria, Ohio.
1900	Stevenson, C. E.	Mogyana	Campinos, San Paulo, Brazil, S. A.
1892	Stewart, Andrew F.	Ches. & Ohio	Huntington, W. Va.
1885	Stewart, O.	Bangor & Aroostook	Oldtown, Maine.
1890	Stillman, H.	Southern Pacific	Sacramento, Cal.
1896	Stout, S. E.	Phila. & Reading	Philadelphia, Pa.
1875	Strode, Jas.	Northern Central	Elmira, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Studer, A. L.	C. R. I. & P.	Horton, Kan.
1892	Sumner, Eben T	Boston & Maine	East Cambridge, Mass.
1892	Sutherland, R. D	Boston, R. B. & Lynn	Boston, Mass.
1899	Suzuki, S.	Kinshui	Moji, Japan.
1868	Swanston, Wm.	P. C. C. & St. L.	Indianapolis, Ind.
1899	Symington, T. H.	Atlantic Coast Line	Wilmington, N. C.
1892	Symons, W. E.	Plant System	Savannah, Ga.
1894	Taft, Wm. H	Boston & Albany	Boston, Mass.
1883	Tandy, H	Supt. Canadian Loco. Works,	Kingston, Ont., Can.
1896	Tawse, Robt.	Ann Arbor	Owosso, Mich.
1893	Taylor, C. M	A. T. & S. F	La Junta, Colo.
1900	Taylor, G. W		Houghton, Mich.
1896	Taylor, Jno.	C. M. & St. P.	Minneapolis, Minn.
1893	Taylor, Wm. H	Wilkesbarre & East.	Stroudsburg, Pa.
1885	Thomas, C. F.	Southern	Alexandria, Va.
1891	Thomas, H. T	Det. & Mackinac.	East Tawas, Mich.
1892	Thomas, J. J., Jr	Mobile & Ohio	Mobile, Ala.
1883	Thomas, W. H.	Southern	Washington, D. C.
1890	Thompson, C. A		Jersey City, N. J.
1896	Thompson, Geo	N. Y. Cent. & Hud. Riv.	Corning, N. Y.
1895	Thompson, W. F	Kings Co. Elev	Brooklyn, N. Y.
1883	Thow, Wm	Government	Sydney, N. S. W.
1892	Todd, Louis C	Boston & Maine	Lyndonville, Vt.
1898	Tollerton, W. J	Oregon Short Line	Salt Lake City, Utah.
1897	Tomlinson, J. J	Mex. Northern	Escalon, Chihuahua, Mex.
1893	Tonge, John	Minn. & St. Louis	Minneapolis, Minn.
1900	Tonkins, W. H.	Lima	Calloa, Peru, S. A.
1896	Tower, G. M.	Lehigh Valley	Sayre, Pa.
1892	Townsend, Jos		Bloomington, Ill.
1896	Tracy, W. L.	Southern	Atlanta, Ga.
1892	Traver, W. H.	Rand Drill Co., Monadnock Block,	Chicago, Ill.
1883	Tregelles, Henry	Care Norton, Megaw & Co.,	Rio de Janeiro, Brazil.
1892	Tremp, A. E.	Ohio Southern	Springfield, Ohio.
1896	Tubbs, F. E.		1018 W. Duval st., Jacksonville, Fla.
1890	Tuggle, S. R.	Houston & Tex. Cent	Houston, Tex.
1899	Turner, A	Lehigh Valley	South Easton, Pa.
1890	Turner, Calvin G	Phil. Wil. & Balto	Wilmington, Del.
1889	Turner, Chas. E.	B. R. & P.	Rochester, N. Y.
1886	Turner, J. S	Fitchburg	Boston, Mass.
1890	Turner, L. H	Pitts. & L. Erie	McKees Rocks, Pa.
1886	Twombly, A. W.	Old Colony	Taunton, Mass.
1883	Twombly, Fred M	N. Y. N. H. & H.	Boston, Mass.
1887	Tynan, F. F	Ferro Carrel de Matanzas,	Matanzas, Cuba.
1890	Tyrrell, Thos. H	Staten I. Rap. Transit.	Whitehall st., N. Y. City.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Vail, A	Western N. Y. & Pa	Buffalo, N. Y.
1898	Van Alstine, D	Chic. Great Western	St. Paul, Minn.
1890	Van Brunt, G. E	Penna. & N.-Western	Bellwood, Pa.
1896	Van Cleve, J. R		Skagway, Alaska.
1891	Vauclain, Samuel M	Baldwin Loco. Works	Philadelphia, Pa.
1898	Vaughan, H. H	Q. & C. Co	Chicago, Ill.
1896	Villasenor, Alberto		San Jose de Costa Rica, C. A.
1892	Vogt, A. S	Pennsylvania	Altoona, Pa.
1899	Vought, J. H	Lehigh Valley	Weatherly, Pa.
1892	Waitt, A. M	N. Y. Central & Hudson River	New York, N. Y.
1900	Walker, E. S	Southern Indiana	Bedford, Ind.
1893	Walker, Henry E	Beyer, Peacock & Co.	Gorton, Manchester, Eng.
1891	Wallis, J. M	Pennsylvania	Altoona, Pa.
1888	Wallis, Philip	Long Island	Richmond Hill, L. I.
1900	Walsh, F. O	A. & W. P.; W. R'y of Ala.	Montgomery, Ala.
1874	Walsh, Thos	Louisville & Nashville	Howell, Ind.
1896	Walton, E. A		Tamaqua, Pa.
1896	Ward, C. A	Bangor & Portland	Bangor, Pa.
1887	Ward, C. F	Duluth, Superior & West.	Cloquet, Minn.
1883	Warren, Beriah		Peoria, Ill.
1882	Warren, W. B	Texas Central	Walnut Springs, Tex.
1883	Watts, Amos H	Cincinnati Northern	Van Wert, Ohio.
1896	Waugh, L. H	G. C. & S. F	Cleburne, Tex.
1887	Webb, F. W	London & North West	Crewe, England.
1892	Weiss, C. P	Erie	Hornellsville, N. Y.
1886	Weisgerber, E. L	Balt. & Ohio	Mt. Clare Shops, Baltimore, Md.
1900	Welch, C. H	Choc. Okla. & Gulf	Little Rock, Ark.
1868	Wells, Reuben	Rogers Loco. Works	Paterson, N. J.
1896	West, A. T	Tabor & Northern	Tabor, Iowa.
1880	West, G. W	N. Y. O. & W	Middletown, N. Y.
1899	Westmark, H. O	Chgo. Bur. & Quincy	Aurora, Ill.
1885	White, A. M	Schenectady Loco. Works	Schenectady, N. Y.
1894	White, E. T	Balto. & Ohio	Mt. Clare, Baltimore, M. D.
1898	Whyte, F. M	N. Y. Cent. & Hudson River	New York.
1899	Wiest, E. N	Man. & North-Eastern	Manistee, Mich.
1894	Wiggin, Chas. H	Boston & Maine	Concord, N. H.
1884	Wightman, D. A	Pitts. Loco. Works	Allegheny, Pa.
1900	Wilbur, I. N	Han. & St. Joseph	Hannibal, Mo.
1891	Wilcox, W. J	A. T. & S. F	Los Angeles, Cal.
1896	Williams, Alfred	Paulista	Paulista, Brazil, S. A.
1891	Williams, E. A	M. St. P. & S. S. M	Minneapolis, Minn.
1887	Wilson, G. F	C. R. I. & P	Chicago, Ill.
1900	Wirt, G	Louis. & Jeff. Bridge Co.	Louisville, Ky.
1898	Witmer, J. W		Marshall, Mich.

JOINED.	NAME.	ROAD.	ADDRESS.
1896	Yohn, C. R.	H. & B. T. Mtn.	Saxton, Pa.
1899	York, F. C	B. A. & Pac.	Junin, Buenos Ayres, Arg. Rep., S. A.
1895	Young, W. H.	Florida So.	Sanford, Fla.
1898	Zerbee, F. J.	C. C. C. & St. L.	Wabash, Ind.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1893	Baker, Geo. H	Metropolitan Bldg., New York City
1898	Basford, G. M	Morse Bldg., New York City
1898	Bates, E. C	Crosby Steam Gage & Valve Co., Boston, Mass.
1890	Crossman, W. D	Manhattan Bldg., Chicago, Ill.
1883	Dean, F. W	55 State st., Boston, Mass.
1896	Fowler, Geo. L	53 Broadway, New York City
1880	Gordon, Alex	Niles Tool Works, Hamilton, Ohio
1895	Goss, W. F. M	Purdue University, Lafayette, Ind.
1889	Hill, John A	256 Broadway, New York City
1899	Kneass, Strickland L	Wm. Sellers Co., Ltd., Philadelphia, Pa.
1897	Moore, E. F	Railroad Commission, Lansing, Mich.
1889	Pomeroy, L. R	Schenectady Loco. Works, Schenectady, N. Y.
1893	Robinson, Harry P	Monadnock Bldg., Chicago, Ill.
1886	Shaw, Thos	915 Ridge st., Philadelphia, Pa.
1899	Smart, R. A	Purdue University, Lafayette, Ind.
1889	Smith, John Y	Doylestown, Pa.
1882	Smith, W. A	Old Colony Bldg., Chicago, Ill.
1899	Street, Clement F	Dayton, Ohio
1871	Wheelock, Jerome	98 Eastern ave., Worcester, Mass.

HONORARY MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1869	Coolidge, G. A		Charlestown, Mass.
1870	Cooper, H. L		Morgan Park, Ill.
1895	Coster, E. L.	Assistant in Mechanical Engineering Columbia University. Residence, Irvington	27 Williams st., New York City.
1870	Divine, J. F	W. & Weldon	Wilmington, N. C.
1881	Eastman, A. G		Sutton, Que.
1871	Forney, M. N		501 Fifth avenue, New York City.
1872	Foss, J. M.	Cent. Vermont	St. Albans, Vt.
1885	Galloway, A	C. H. & I	Indianapolis, Ind.
1869	Graham, Chas		401 Madison avenue, Scranton, Pa.
1870	Hodgman, S. A		Lobdell Car Wheel Works, Wilmington, Del.
1874	Jeffery, E. T	Denver & Rio Grande	Denver, Colo.
1868	Johann, Jacob		1003 South Seventh street, Springfield, Ill.
1868	Kinsey, J. I	Lehigh Valley	Easton, Pa.
1893	Leeds, John H		318 Howard avenue, New Haven, Conn.
1878	Maglenn, Jas.	Seaboard Air Line	Raleigh, N. C.
1891	McKenna, John	I. D. & S. W	Indianapolis, Ind.
1871	Miles, F. B		Bement & Miles, Philadelphia, Pa.
1872	Philbric, J. W.		Waterville, Me.
1873	Prescott, G. H		Logansport, Ind.
1869	Richards, George		14 Auburn street, Roxbury, Mass.
1870	Robinson, W. A.		Hamilton, Ont.
1869	Sellers, Morris		Western Union Bldg., Chicago, Ill.
1888	Sheppard, F. L.	Pennsylvania	Altoona, Pa.
1883	Sullivan, A. W.	Ill. Cent	Chicago, Ill.
1869	Thompson, John		137 Webster street, East Boston, Mass.
1870	Towne, H. A		236 First avenue, Minneapolis, Minn.
1870	Williams, E. H.		Baldwin Loco. Works, Philadelphia, Pa.

PROCEEDINGS.

The Thirty-third Annual Convention of the American Railway Master Mechanics' Association was called to order at 10 A.M. on Thursday, June 21, 1900, in the Theater Saratoga, Saratoga Springs, New York, by President J. H. McConnell.

The following members were present during the convention:

Appleyard, W. P.
Aiken, C. L.
Allen, G. S.
Arp, W. C.
Antz, Oscar.
Atkinson, R.
Aldcorn, T.
Baker, C. F.
Billingham, Jos.
Boon, J. M.
Butcher, G. W.
Brown, Angus.
Bartlett, H.
Bradeen, A. A.
Browne, T. R.
Bean, S. L.
Beckert, A.
Branch, G. E.
Brangs, P. H.
Blackall, R. C.
Brown, D.
Bryan, H. S.
Buchanan, A., Jr.
Brown, W. A.
Barnes, J. B.
Bushnell, R. W.
Butler, L. M.
Bates, E. C.
Bentley, H. T.
Basford, G. M.
Clifford, C. J.
Crossman, W. D.
Cory, C. H.
Carney, J. A.
Chambers, J. S.
Christopher, J.
Clark, F. H.
Cook, J. S.
Cunningham, J.
Cullinan, J.
Cole, F. J.
Chase, F. A.
Cross, W.
Carson, M. T.
Cleaver, F. C.
Coolidge, G. A.
Courtney, D. C.
Cushing, G. W.
Dallas, N. C.
Davis, E. E.
Davis, M. R.
Davis, W. J.
Deems, J. F.
Dolan, S. M.
Dunn, A. J.
Dean, F. W.
Delaney, C. A.
Delano, F. A.
Davisson, F. E.
Downing, T. M.
Ennis, W. C.
Ettenger, R. L.
Ewing, J. J.
Elden, E.
Foulk, Jno.
Fowler, G. L.
Frey, N.
Fuller, C. E.
Feeley, T. M.
Fergusson, G. A.
Forney, M. N.
Forsythe, A.
Forsyth, W.
Garstang, W.
Gordon, H. D.
Garrison, P. E.
Gibbs, G.
Graham, J. A.
Graham, J. A.
Gentry, T. W.
Gillis, H. A.
Gilmore, W. L.
Goss, W. F. M.
Givin, F. A.
Hill, R.
Hone, A. C.
Higgins, S.
Holman, W. L.
Hoffman, R. F.
Henderson, G. R.
Hufsmith, F.
Hill, J. W.
Hayward, H. S.

Hawksworth, D.
Haskell, B.
Hudson, H. G.
Haselton, G. H.
Hyndman, F. T.
Howard, C. H.
Hassman, Wm.
Inge, T. S.
Jackson, O. H.
Johnstone, F. W.
Jerome, E. W.
Johnson, R. H.
Joughins, G. R.
Kneass, S. L.
Kenney, G. W.
Kistler, L.
Kells, W.
Laird, A.
Lewis, W. H.
Lee, C. W.
Leech, H. L.
Lawler, F. M.
Lowell, W. W.
Lake, E. M.
La Lime, E.
Lawes, T. A.
Macbeth, J.
MacKinnon, G. S.
Marshall, W. H.
McNaughton, J. M.
McIntosh, Wm.
Maher, P.
McConnell, J. H.
Miller, G. A.
Millen, Thos.
Miller, E. A.
McCormick, A.
McCuen, J. P.
McMasters, C. J.
Marshall, E. S.
Minshull, P. H.
Mellin, C. J.
Michael, J. B.
Morris, W. S.
Medway, John.
Mackenzie, J.
Noble, L. C.
Nuttall, W. H.
Nettleton, W. A.
Neuffer, J. G.
O'Herin, W.
Peck, P. H.
Pitkin, A. J.
Prince, S. F., Jr.
Pflager, H. M.
Pennington, J. H.
Pomeroy, L. R.
Purves, T. B., Jr.
Quayle, R.
Roberts, M.
Rhodes, L. B.
Rhodes, G. W.
Riley, G. N.
Rickert, M.
Rosing, W. H. V.
Robinson, F.
Rumney, T.
Sague, J. E.
Stout, S. E.
Sinclair, Angus.
Small, H. J.
Smith, R. D.
Soule, R. H.
Schaefer, H.
Slack, J. R.
Stansbury, C. M.
Stewart, O.
Symons, W. E.
Stewart, A. F.
Sutherland, R. D.
Smith, W. T.
Smart, R. A.
Seley, C. A.
Thomas, W. H.
Thompson, J.
Thompson, W. T.
Traver, W. H.
Tyrrell, T. H.
Thomas, H. T.
Thomas, C. F.
Tawse, R.
Tonge, J.
Taylor, J.
Turner, C. G.
Turner, J. S.
Van Alstine, D.
Vauclain, S. M.
Vought, J. H.
Walsh, F. O.
Whyte, F. M.
White, A. M.
Wirt, G.
West, G. W.
Watts, A. H.
Waitt, A. M.
Wilber, J. N.
Wells, R.

THE PRESIDENT: Ladies and Gentlemen,—The success of all organizations depends entirely upon how they are started. It has been a custom ever since the organization of the Master Mechanics' Association to commence the deliberations with prayer. I would therefore ask you to rise while we are led in prayer by the Rev. Dr. Jump, pastor of the First Methodist Church of Saratoga.

Prayer was then offered by the Rev. Delos Jump.

THE PRESIDENT: Ladies and Gentlemen,—We have with us this morning a gentleman who has kindly consented to deliver a short address on the opening of this convention. This gentleman is known to you all. He is also known from Maine to California. It is not necessary that he should be introduced, but I will now take pleasure in introducing to you Mr. A. J. Pitkin, the Vice-President of the Schenectady Locomotive Works, who will now address you. (Applause.)

MR. PITKIN: Mr. President and Gentlemen of the Master Mechanics' Association,— On receiving, a few days since, the courteous letter from you, Mr. President, requesting me to make the address of welcome at the opening of your convention, I thought some mistake had been made, as I am neither native born nor yet a resident of this beautiful place. Realizing, however, the time was quite short for you to make plans for correcting the error, I agreed to tell you how glad we are to see you here in our midst. I think I can safely say this, by proxy at least, as my principal associate in business and president of our works is a resident of good standing and, I notice, comes to his home here early in the spring and is one of the last to leave in the fall. We are glad you are here for one reason — that we do not have to travel very far to meet you. You know one is always content, when a tedious journey is to be taken, to have the other fellow do the traveling. I think your friends, the supply men, will bear me out in this statement. Then we in the locomotive business have been so busy of late hustling to get out your orders that we have had little chance to travel, and, I fear, are a trifle out of practice — a condition, however, which, present indications would point, may be subject to a change.

But most of all we are glad you can come to this quiet summer resort, leaving the care of the daily routine of work behind and enjoy the benefits of the change of scene and thought.

I think there is something in the atmosphere here that is conducive to the success of a convention, aside from the fact that the best of accommodations can be had for all, as probably no place in the country is more favored in this respect. Here for a few days you will be able to turn your thoughts from the detail of daily work to the broader view of what the world needs in your line.

When we come to think that the locomotive has to earn practically every dollar that comes into the treasury of a given road, the necessity of correct design for the service required assumes large proportions. This present gathering will doubtless, as in the past, assist each of you in catching that broader view of your responsibility as will enable you to assist the management materially in solving the problem of transporting freight and passengers under given conditions at the least possible expense. Your efforts in this direction have already been crowned with success, placing the American railroad in the proud position of being able to carry a ton of freight a given distance for far less than is done in any other country in the world, and for comfort and speed in traveling one does not need to leave home to find the best.

These facts are now recognized by many of the leading railroads abroad, and our American designs are fast finding favor where we least hoped for their adoption. One instance of this as an illustration may be of interest. In recent conversation with one of the officials of a prominent foreign railroad the remark was made that he was learning to like the American design of locomotive with its bar frame and simplicity of construction as being more durable under the severe strain of service, and the cost was very much less than his standard designs.

When one comes to consider that with the use of a lump of coal that you can hold in the palm of your hand, weighing 1¾ pounds, sufficient energy is utilized by the modern locomotive to transport a car containing 1,000 bushels of wheat a mile, the high degree of perfection of design is more nearly realized. This fact alone can well cause the Governor of our Empire State to pause and consider before approving a plan for expending the many millions on the Erie Canal, as were the work completed, with further efforts on your part along the lines of reduced cost of movement of freight, the boatmen may find their occupation without profit. May the boatmen be spared the further humiliation and the State the expense.

Your various shops, with their many conveniences for performing the work quickly and at the least possible cost, evidence the deep thought that has been given to solving the question of reduced cost of maintenance. You must know the locomotive builder appreciates these points very keenly, and some of you will not have to go far to see some of the creatures of your own brain hard at work helping to reduce the cost of construction, and produce, at the same time, a more efficient and perfect locomotive. Not only the reading and discussion of the various papers in convention will be of value, but the personal intercourse as you touch elbows on the hotel piazza or on the drive, will enable you to see where you can profit by the other man's experience in meeting the difficult problems that confront you in your own especial work. In fact, I have heard many of you remark that the most valuable information you gained at the convention was obtained in this personal exchange of thought.

So we are glad you have come to this delightful place where there is piazza room to spare and pleasant drives to give you the opportunity of such intercourse.

May your gathering here be a source of profit to you all and may you find Saratoga so enjoyable that you will want to come again soon. (Applause.)

President McConnell then read the following address:

The general opinion among members of this Association that Saratoga is a good place to hold the convention is borne out by the fact that we have assembled here for the fifth time in the history of the Association.

The cordial manner in which we have always been received, the many attractions and the beautiful surroundings justify this opinion.

From the reports of the Secretary and Treasurer you will find the affairs of the Association are in a very satisfactory condition. During the last year 58 new active members have been received and 3 new associate members; one name taken from the associate list and added to the honorary list, making a total of 61.

During the year 7 active members and 1 associate member have resigned, 8 active members and 1 honorary have died, 32 active members dropped from the rolls, making at this time the following: Active 620, honorary 26, associate 19; an increase of 12.

Those who have been lost to the Association by death are: John Torrance, E. & T. H.; W. H. Harrison, B. & O.; J. B. Glover, M. & N. G.; J. G. Tomlinson, N. O. & N. E.; James Cullen, N. C. & St. L.; George B. Ross, Consolidated Brake Shoe Company; Thomas Carmody, Erie; J. E. Battye, Nor. & West.; W. H. Stearns.

The report of the Interstate Commerce Commission shows, on June 30, 1898, 36,234 locomotives in service. The increase in two years would indicate about 37,000 in service at the present time on 189,236 miles of railroad. The past year has been the most remarkable in the history of this country. Manufacturing concerns of all kinds have been prosperous. Steel and iron mills have been unable to supply the demands. Railroads have shown an increase in earnings and many railroads did not own sufficient equipment to handle the increased tonnage. The advance in the cost of material used in new and repair work has been more rapid than any previous year. An average increase of forty per cent in ten months of 1899 shows the immense demand. Locomotive builders have been unable to handle all the work offered them in the required time.

During the year 1899, 2,196 locomotives were built in the United States, costing about $25,000,000; 1,716 were delivered to American railroads; 480 were shipped to foreign countries, seventy per cent of the foreign orders being sent to Europe, Asia and Africa, thirty per cent to Mexico, Canada, South America and the West Indies. Of the entire output of American locomotives, twenty-one and four-tenths per cent were foreign orders. The American locomotive is making friends in all parts of the world. England and France purchased our locomotives. While England, to a certain extent, has adhered to their own designs, France has accepted the American locomotive with few modifications.

The year 1899 has been a year of large locomotives. Reports for the year show four types of freight locomotives having a weight of 218,000, 225,000, 230,000 and 232,000 pounds respectively, with a weight on drivers of 193,000, 198,000, 202,000 and 208,000 pounds, heating surface 3,203 square feet, 3,322 square feet, 3,500 square feet and 4,105 square feet. One with cylinders 23 by 32 inches, two with cylinders 23 by 30 inches, and one compound with cylinders 18 and 30 by 30 inches.

Locomotive tenders were built with water capacity of 7,000 gallons. A number of roads have made 5,000-gallon tanks their standard, while others have adopted a 6,000-gallon tank. The use of cast steel in locomotive construction has increased very largely. Cast steel for frames finds many advocates in the mechanical departments of railroads as well as locomotive builders. A number of engines were constructed this year as well as last year with cast steel frames. Steel castings have displaced cast iron to a great extent for driving-wheel centers, driving boxes and cylinder heads. With the improved method of steel making and increase in number of steel foundries, a more extensive use of steel may be looked for. The difficulty of obtaining steel castings in the past has, to a certain extent, limited the amount used in the last year.

During the year 1899 a number of engines were constructed, showing an increase of thirty-three per cent in the use of steel castings over three years ago.

Nickel steel has not come into very general use. Mechanical departments are advancing cautiously in this direction. It has been used to a limited extent for driving axles, crank pins and piston rods.

The use of piston valves has increased in the last year. On simple engines improved forms have been introduced, and having passed the experimental stage we may look to see them advance rapidly in favor.

The past year has shown the most rapid advance in weight on driving wheels, tractive power and increased heating surface of our locomotives.

The tendency is all in the direction of increased tonnage in freight trains. Large sums of money are being spent by trunk lines in cutting down grades and reducing curvature in order to reduce the cost per ton-mile for handling freight. The constant tendency of a decline in freight rates can only be offset by the increased power of the locomotive. In passenger service the same development of the locomotive has taken place as with the freight engine. A few years ago 80,000 pounds weight on the driving wheels of an eight-wheel locomotive was considered excessive. It has now reached 94,000 pounds on an eight-wheel locomotive. In passenger service ten-wheel locomotives are being built with 130,000 pounds weight on the driving wheels and a heating surface of 2,500 square feet. The passenger service throughout the country has increased in the weight of trains as well as in speed.

With the large locomotives in service when compared on a mileage basis, the cost per mile for fuel, repairs and lubrication shows an increase. Compared with several years ago on the tonnage basis, the cost per ton-mile for repairs, fuel, oil and other supplies is largely in favor of the recent locomotive.

The compound locomotive is gradually gaining in favor. During the year 1899, 330 engines of this class were built in the United States.

The improvements during the year have not all been confined to locomotives. Shop practices have advanced to a marked degree. New shops are now largely supplied with electricity for driving machinery and it is displacing the stationary engine and line shafting. New tools electrically driven are coming into general favor and the economy of such machines can not be questioned. Compressed air has found its way in all shops, both large and small. The air compressor is of as much value in the railroad shop today as the stationary engine. The manufacturers of compressed-air tools have brought out new designs and by their use the work is performed more economically. The modern shops are supplied with both electricity and compressed air. Both have their advantages and neither can displace the other on certain lines of work. For driving machinery electricity is more economical and superior to the old line shafting and stationary engine. For small tools compressed air is superior to electricity and more economical.

The subjects before the Association this year are all of very interesting character and the committees are to be commended for their reports presented to the convention. Several of the subjects were carried over from last year and will be presented with additional information and recommendation by the committees. Of the new subjects, compound locomotives, piston valves, oil and various bearing metals, power driven by electricity versus shafting, and the best types of stationary boilers for shop purposes, will give new, interesting and valuable information.

Desire particularly to call your attention to the report of the committee on Subject No. 9, which bears in general on the increased usefulness of the Association. The report as presented by the committee shows very careful and thorough consideration of the subject and embraces a wide range of research. Many of the subjects are treated generally and the recommendations advanced by the committees are worthy of your careful and earnest consideration.

Desire also to call your attention to Subject No. 2, which is probably receiving more attention throughout the country than any other subject before the Association at this time—"The Advantage of the Ton-Mile Basis for Motive Power Statistics." The question of a uniform performance sheet for all roads has been under discussion before by this Association.

A number of roads throughout the country have abandoned the performance sheet on the mileage basis. There being no uniformity in making up these reports as a means of comparison, except from year to year on the same road, they were of no value. The system adopted of keeping the records on the tonnage basis varies almost as widely at the present time as the old system of reports on the mileage basis. Until there is a uniform system adopted by all roads no correct comparison can be made between the different companies. It is the practice now with some roads, in showing the number of ton-miles, to add the weight of the locomotive and caboose. Other roads show the actual ton-miles in the train and do not consider the weight of the engine or caboose and allow nothing but actual mileage between terminals. Some reports are made up in the office of the auditor of the road, while others are made by the superintendent of motive power. It is to be hoped at this session a uniform system can be agreed upon that all roads can adopt.

Desire to thank the officers, the committees and the Association for the uniform kindness and consideration shown on all occasions. This, with the assistance so cheerfully rendered, has made the duties of the President a very pleasant task.

THE PRESIDENT: Ladies and Gentlemen,—We have a communication from the Schenectady Locomotive Works, which I will ask the Secretary to read.

The Secretary read the following letter:

SCHENECTADY, N. Y., May 24, 1900.

Mr. J. W. Taylor, Secretary American Railway Master Mechanics' Association, 667 Rookery, Chicago, Ill.:

DEAR SIR,—We desire to extend an invitation to the Master Mechanics, their wives and friends, to visit and inspect our works during the convention at Saratoga. A suitable train will be arranged for their convenience and we will gladly furnish a light lunch. Will you kindly extend this invitation to the Association on their convening at Saratoga, that we may arrange accordingly.

We feel that this visit will be of especial interest, as we have a larger amount of work under process than ever before in the history of our works, and quite a number of different designs of locomotives can be shown.

Yours very truly,
THE SCHENECTADY LOCOMOTIVE WORKS,
A. J. PITKIN,
Vice-President and General Manager.

THE PRESIDENT: Gentlemen, what is your pleasure with the invitation?

MR. GEORGE W. WEST: I move that the invitation of the Schenectady Locomotive Works be accepted and that we name Friday; that the meeting adjourn on Friday at 12:30 and take the train at 1.

THE PRESIDENT: Ladies and Gentlemen,— It has been moved and seconded that we accept the invitation so kindly extended by the Schenectady Locomotive Works, and that this Association adjourn tomorrow, Friday, at 12:30 and take the train at 1 o'clock for Schenectady.

The motion was carried.

THE PRESIDENT: Mr. Pitkin, we will be glad to take lunch with you at Schenectady tomorrow.

Ladies and Gentlemen,—We will now have an intermission of five minutes. It is customary to take this intermission in order to give any parties who may desire to do so an opportunity to leave the hall. We should, however, be delighted to have you all remain if you can find it convenient to do so.

A recess of five minutes was then taken.

THE PRESIDENT: Gentlemen, the first order of business for consideration this morning will be your action on the printed minutes of the last meeting of the Association. What is your pleasure?

MR. WILLIAM GARSTANG: I move they be adopted as printed.

The motion was carried.

THE PRESIDENT: We will now listen, gentlemen, to the reports of the Secretary and Treasurer.

Secretary Taylor read his report, as follows:

At the beginning of the present fiscal year the Association was composed of the following members:

Active	609
Honorary	26
Associate	18
Total	653

During the year seven active members resigned, eight died and thirty-two were dropped from the roll of membership for non-payment of dues and other causes. Fifty-eight new members were added, making an increase of eleven members in the active membership list.

Of the associate members, one resigned, one was transferred to the honorary membership list and three new members added, making an increase of one member in the list.

Of the honorary members, one died and one member added by transfer.

The membership at the present time is as follows:

Active members	620
Associate members	19
Honorary members	26
Total	665

According to the records of the Secretary, the following members died during the year: Active members—W. H. Harrison, J. G. Tomlinson, John Torrance, J. B. Glover, George B. Ross, James Cullen, Thomas Carmody and J. E. Battye. Honorary member—W. H. Stearns.

The receipts and disbursements since the last report up to and including June 9, the date of closing the books preparatory to this report, are as follows:

RECEIPTS.

To Dues Collected from Members	$2,835.00
To Sale of Proceedings	1,134.95
Total	$3,969.95

DISBURSEMENTS.

Paid Reporting Convention, 1899	$ 173.50
" Expenses Convention, 1899	59.39
" Printing	1,591.34
" Electros, Zinc Cuts, etc	98.53
" Stamps and Stamped Envelopes	214.46
" Discount	12.10
" Office Supplies	12.50
" Office Rent, Eleven Months	157.08
" Revenue Stamps	1.75
Carried forward	$2,320.65

Brought forward	$2,320.65
Paid Telegrams	14.55
" Expenses, Committees	101.85
" Surety Bonds, Secretary and Treasurer	21.80
" Engrossing Resolutions	20.00
" Salary, Secretary, June 20, 1899, to June 20, 1900.	1,200.00
" Balance remitted to Treasurer	291.10
Total	$3,969.95

There are no unpaid bills against the Association, and all the funds belonging to the Association are in the hands of the Treasurer.

The amount of dues unpaid is $800, and a detailed statement of members in arrears is attached for the information of those interested.

A statement, in detail, showing the dues collected during the year, is attached hereto and forms a part of this report.

The four scholarships of the Association at the Stevens' Institute of Technology are taken and the first vacancy to occur will be next fall.

Jos. W. Taylor,
Secretary.

DETAILS OF DUES COLLECTED FROM MEMBERS.

1899.			
June	10	H. T. Bruck	$ 10.00
"	10	John Howard	5.00
"	10	Z. T. Sprigg	5.00
"	10	Charles Blackwell	5.00
"	10	F. G. Lauer	5.00
"	10	G. W. Hepburn	5.00
"	10	P. J. Nolan	5.00
"	10	T. J. Hatswell, Jr.	5.00
"	10	G. S. Allen	5.00
"	10	R. Allin	5.00
"	10	W. C. Arp	5.00
"	10	R. Atkinson	5.00
"	10	J. D. Barnett	5.00
"	10	J. E. Battye	5.00
"	10	A. J. Beltz	5.00
"	10	J. Bisset	10.00
"	10	R. C. Blackall	5.00
"	10	J. M. Boon	5.00
"	10	C. K. Bowles	5.00
"	10	G. E. Branch	5.00
"	10	D. Brown	5.00
		Carried forward	$ 115.00
		Brought forward	$ 115.00
June	10	W. A. Brown	5.00
"	10	T. R. Browne	5.00
"	10	T. L. Chapman	10.00
"	10	Joseph Cockfield	5.00
"	10	D. S. Cooper	5.00
"	10	G. W. Cushing	5.00
"	10	W. C. Dallas	5.00
"	10	C. A. Delaney	5.00
"	10	T. M. Downing	5.00
"	10	M. J. Drury	5.00
"	10	M. R. Davis	5.00
"	10	J. Ellis	5.00
"	10	W. C. Ennis	5.00
"	10	A. Gardner	5.00
"	10	W. Garstang	5.00
"	10	T. W. Gentry	10.00
"	10	H. D. Gordon	5.00
"	10	J. T. Gordon	10.00
"	10	J. A. Hill	5.00
"	10	R. Hill	5.00
"	10	W. L. Holman	5.00
		Carried forward	$ 235.00

		Brought forward...$	235.00
June	10	J. C. Homer	5.00
“	10	T. S. Inge	10.00
“	10	O. H. Jackson	5.00
“	10	G. James	5.00
“	10	D. M. King	5.00
“	10	E. La Lime	5.00
“	10	J. L. Lawrence	5.00
“	10	H. L. Leach	5.00
“	10	J. Losey	15.00
“	10	A. G. Machesney	5.00
“	10	J H McConnell	5.00
“	10	Allen McDuff	5.00
“	10	J. McNaughton	5.00
“	10	C. J. Mellin	5.00
“	10	J. B. Michael	5.00
“	10	G. A. Miller	5.00
“	10	R. Miller	5.00
“	10	P. H. Minshull	5.00
“	10	G. T. Neubert	5.00
“	10	J. G. Neuffer	5.00
“	10	N. W. Norsworthy	10.00
“	10	W. H. Nuttall	5.00
“	10	J. O'Brien	5.00
“	10	W. H. Owens	5.00
“	10	P. H. Peck	5.00
“	10	A. Pilsbury	5.00
“	10	C. H. Quereau	5.00
“	10	J. A. Quinn	10.00
“	10	O. H. Reynolds	5.00
“	10	C. B. Royal	5.00
“	10	T. Rumney	5.00
“	10	J. E. Sague	5.00
“	10	H. Schaefer	5.00
“	10	W. Smith	5.00
“	10	R. H. Soule	5.00
“	10	O. Stewart	5.00
“	10	E. T. Sumner	5.00
“	10	W. Swanston	5.00
“	10	W. H. Thomas	5.00
“	10	John Tonge	10.00
“	10	G. M. Tower	5.00
“	10	W. H. Traver	5.00
“	10	T. H. Tyrrell	5.00
“	10	F. J. Zerbee	5.00
		Carried forward...$	485.00

		Brought forward...$	485.00
June	10	E. N. Weist	5.00
“	10	G. W. West	5.00
“	10	F. B. Smith	5.00
“	24	F. H. Neward	5.00
“	24	W. L. Hoffecker	5.00
“	24	L. C. Todd	5.00
“	24	J. O. Pattee	5.00
“	24	H. J. Rainesford	5.00
“	24	T. Carmody	5.00
“	24	E. A. Walton	10.00
“	24	J. Wayne Nichols	20.00
July	1	J. C. Hayden	5.00
“	7	W. B. Warren	5.00
“	7	W. H. V. Rosing	5.00
“	8	R. D. Smith	5.00
“	8	B. Warren	5.00
“	8	C. H. Howard	5.00
“	8	P. Leeds	5.00
“	8	F. H. Stevens	5.00
“	10	R. J. Gross	5.00
“	10	J. H. Pennington	5.00
“	10	G. R. Henderson	5.00
“	10	L. B. Paxson	5.00
“	10	J. B. Barnes	5.00
“	10	S. Higgins	5.00
“	10	J. L. Driscoll	5.00
“	10	J. B. Johnson	5.00
“	10	P. P. Foller	5.00
“	10	L. R. Pomeroy	5.00
“	10	J. E. Keegan	5.00
“	10	Geo. L. Dickson	5.00
“	10	W. H. Taylor	5.00
“	10	J. Hainen	5.00
“	10	B. Haskell	5.00
“	10	E. M. Herr	5.00
“	10	F. Hedley	5.00
“	11	H. M. Pflager	5.00
“	11	G. W. Rhodes	5.00
“	11	F. T. Hyndman	5.00
“	11	L. C. Noble	5.00
“	12	Alex. Mitchell	5.00
“	12	John Mackenzie	5.00
“	12	F. A. Delano	5.00
“	12	S. T. Balkam	5.00
		Carried forward...$	725.00

		Brought forward...$	725.00
July	12	H. Bartlett.......	5.00
"	12	C. H. Wiggins ...	5.00
"	12	J. J. Ellis	5.00
"	12	R. F. Hoffman...	5.00
"	12	E. S. Marshall ...	5.00
"	13	F. H. Clark......	5.00
"	13	F. J. Cole........	5.00
"	13	A. M. Waitt	5.00
"	14	E. D. Bronner ...	5.00
"	14	W. H. Taft	5.00
"	14	E. Ryan	5.00
"	14	H. Elliott........	5.00
"	14	John Hewitt	5.00
"	14	W. J. McLean....	5.00
"	14	R. Moran........	5.00
"	14	J. S. Turner	5.00
"	14	N. W. Sample ...	5.00
"	14	H. O. Westmark.	5.00
"	15	G. L. Potter	5.00
"	15	C. H. Barnes	5.00
"	15	W. K. Christie....	5.00
"	15	S. M. Vauclain...	5.00
"	15	A. B. Johnson ...	5.00
"	15	W. L. Austin	5.00
"	15	W. H. Lewis, D.L.W.	5.00
"	17	T. S. Lloyd......	5.00
"	17	Wilbur Green....	5.00
"	17	W. S. Morris.....	5.00
"	17	C. M. Stanbury ..	5.00
"	17	D. Hawksworth..	5.00
"	17	C. F. Lape.......	5.00
"	17	Thomas Shaw ...	5.00
"	17	C. F. Baker......	5.00
"	17	C. P. Weiss.....	5.00
"	17	Jerome Wheelock	5.00
"	17	William Fuller ...	5.00
"	17	H. J. Small	5.00
"	17	L. B. Rhodes	5.00
"	18	W. E. Symons ...	5.00
"	18	James Cullen.....	5.00
"	18	A. B. Minton.....	5.00
"	18	Joseph Lythgoe ..	5.00
"	18	F. M. Whyte.....	5.00
"	18	J. H. Setchel.....	5.00
		Carried forward.. $	945.00

		Brought forward...$	945.00
July	19	C. G. Turner.....	5.00
"	19	F. F. Tynan	5.00
"	20	J. W. Roberts....	5.00
"	20	G. N. Riley......	5.00
"	20	G. W. Buck	5.00
"	20	C. E. Hogsett....	5.00
"	20	W. H. Lewis	5.00
"	20	William Renshaw	5.00
"	20	Owen Clarke.....	5.00
"	20	A. E. Mitchell....	5.00
"	20	G. D. Brooke....	5.00
"	20	E. L. Weisgerber	5.00
"	21	H. N. Sprague...	5.00
"	21	W. H. Brehm....	5.00
"	22	Thomas Millen...	5.00
"	22	P. H. Murphy....	5.00
"	22	R. H. Briggs.....	5.00
"	24	F. Mertscheimer .	5.00
"	24	J. W. Addis......	5.00
"	24	F. C. Cleaver	5.00
"	24	J. W. Sanford....	5.00
"	24	A. J. Pitkin	5.00
"	24	I. W. Fowle	5.00
"	24	R. C. Esson	5.00
"	24	William O'Herin.	5.00
"	24	William Laing ...	5.00
"	24	C. E. Rettew	5.00
"	24	A. Vail..........	5.00
"	24	F. A. Chase......	5.00
"	25	S. R. Tuggle.....	5.00
"	26	William Buchanan	5.00
"	26	J. D. Justice	5.00
"	26	John Horrigan ...	5.00
"	26	J. A. Graham	5.00
"	26	John S. Cook	5.00
"	27	E. A. Williams...	5.00
"	27	C. M. Babcock...	5.00
"	27	James Hinchey...	5.00
"	27	S. L. Knease.....	5.00
"	27	E. C. Bates	5.00
"	28	A. L. Moler......	5.00
"	28	F. Hufsmith	5.00
"	28	G. F. Wilson	5.00
"	28	J. H. Manning....	5.00
		Carried forward...$	1,165.00

Brought forward...$1,165.00

July	29	L. H. Waugh....	5.00
"	29	J. A. Hansgen ...	5.00
"	29	W. S. Hancock ..	5.00
"	29	A. A. Maver	15.00
"	31	F. W. Dean	5.00
"	31	J. L. Greatsinger.	5.00
"	31	Harry Pollitt.....	5.00
"	31	G. P. Fisher	10.00
"	31	C. E. Turner.....	5.00
Aug.	2	A. A. Braden	5.00
"	2	W. L. Gilmore...	5.00
"	2	E. E. Davis......	5.00
"	2	T. A. Lawes	5.00
"	2	H. E. Walker....	5.00
"	2	A. G. Leonard...	5.00
"	3	J. J. Ryan........	5.00
"	5	J. A. Hanglin	5.00
"	5	R. Quayle	5.00
"	5	Allen Cooke	5.00
"	5	James W. Hill ...	5.00
"	5	V. B. Lang	5.00
"	5	A. McCormick ...	5.00
"	5	A. Sinclair.......	5.00
"	5	John Gill	5.00
"	7	L. B. Heers......	5.00
"	7	John W. Cloud...	5.00
"	8	T. W. Macfarlane.	5.00
"	9	M. M. Reid......	5.00
"	9	R. W. Bushnell ..	5.00
"	9	Jas Cunningham..	5.00
"	12	A. Hendee.......	5.00
"	12	H. T. Thomas ...	5.00
"	14	F. W. Johnstone .	5.00
"	14	J. E. Muhlfeld....	5.00
"	14	J. F. Dunn.......	5.00
"	14	T. W. Place	5.00
"	17	F. D. Casanave ..	5.00
"	17	A. S. Vogt	5.00
"	17	W. W. Atterbury.	5.00
"	21	M. Rickert.......	5.00
"	21	H. Schlacks......	5.00
"	21	D. O'Leary......	5.00
"	21	P. Maher	5.00
"	21	James Strode	5.00

Carried forward...$1,400.00

Brought forward...$1,400.00

Aug.	21	H. S. Hayward ..	5.00
"	21	John D. Campbell	5.00
"	22	Alexander Shields	5.00
"	22	G. W. Stevens ...	5.00
"	25	R. M. Galbraith..	5.00
"	25	Tracy Lyon......	5.00
"	25	N. Frey..........	5.00
"	26	W. J. Tollerton ..	5.00
"	28	S. P. Bush.......	5.00
"	29	J. N. Barr........	5.00
"	29	Alfred Lovell	5.00
"	30	Thomas Downing	10.00
"	31	J. J. Tomlinson ..	5.00
Sept.	2	H. H. Vaughan..	5.00
"	2	H. S. Bryan......	5.00
"	2	F. B. Miles	5.00
"	4	E. A. Benson	5.00
"	4	J. R. Groves.....	5.00
"	6	J. L. Brown......	5.00
"	13	John Medway ...	5.00
"	13	W. F. M. Goss...	5.00
"	13	R. A. Smart	5.00
"	13	William Thow ...	5.00
"	13	J. M. Davies	5.00
"	13	James Cullinan...	5.00
"	13	John Hair	5.00
"	15	G. W. Butcher...	5.00
"	15	R. H. Johnson ...	5.00
"	15	I. N. Kalbaugh..	5.00
"	18	P. Wallis	5.00
"	18	A. E. Erskine....	5.00
"	18	C. E. Stevenson..	5.00
"	20	W. Augustus.....	5.00
"	20	A. W. Twombly .	5.00
"	20	A. Villasenor	5.00
"	25	C. F. Thomas....	5.00
"	25	P. E. Garrison ...	5.00
"	27	D. Van Alstine...	5.00
"	27	G. Knapp........	5.00
"	27	J. Kennedy	10.00
"	27	J. G. Beaumont ..	5.00
"	27	T. F. Rotheram..	5.00
"	27	D. A. Wightman .	5.00
"	27	Alex Gordon	5.00

Carried forward...$1,630.00

		Brought forward...	$1,630.00
Sept.	29	H. M. C. Skinner	5.00
"	29	P. T. Lonergan	5.00
Oct.	2	E. A. Miller	5.00
"	3	A. C. Hinckley	5.00
"	7	L. H. Spillard	5.00
"	10	F. W. Webb	5.00
"	10	William Forsyth	5.00
"	12	W. J. Wilcox	5.00
"	12	L. M. Butler	5.00
"	19	E. V. Sedgwick	10.00
"	20	J. M. Keith	5.00
"	24	A. V. Macdonald	5.00
"	28	Henry Tregelles	5.00
Nov.	2	George L. Fowler	5.00
"	4	S. M. Dolan	5.00
"	6	T. W. Heintzelman	5.00
"	6	W. J. Hemphill	5.00
"	9	Calvin Skinner	5.00
"	13	James A. Egan	5.00
"	16	Joseph R. Spragge	5.00
"	18	H. C. Smith	5.00
"	20	J. S. Chambers	5.00
"	20	R. O. Cumback	5.00
"	22	W. F. Dixon	10.00
"	23	H. A. Childs	5.00
"	23	L. A. Shepherd	5.00
"	24	T. H. Symington	5.00
"	27	H. D. Ellis	5.00
"	29	Lester I. Knapp	5.00
"	29	T. W. Gibb	5.00
Dec.	1	S. Suzuki	5.00
"	6	H. Wade Hibbard	5.00
"	11	James Macbeth	5.00
"	16	George Gibbs	5.00
"	18	Amos Turner	5.00
"	18	A. Mitchell	5.00
"	18	W. Cross	5.00
"	20	Angus Brown	5.00
"	22	J. J. Connolly	5.00
"	28	Charles DeGress	5.00
"	28	Charles H. Cory	5.00
1900			
Jan.	2	W. H. Marshall	5.00
"	2	A. W. Belcher	5.00
		Carried forward...	$1,855.00

		Brought forward..	$1,855.00
Jan.	3	James Fitzmorris	5.00
"	3	F. J. Leigh	5.00
"	3	H. D. Page	10.00
"	3	John Taylor	5.00
"	3	A. J. Cromwell	5.00
"	3	W. A. Nettleton	5.00
"	4	C. H. Doebler	10.00
"	4	Willard Kells	5.00
"	4	J. R. VanCleve	5.00
"	4	J. P. McCuen	5.00
"	4	G. M. Basford	5.00
"	4	L. H. Turner	10.00
"	4	C. R. Yohn	5.00
"	4	C. J. Cooper	10.00
"	4	C. A. DeHaven	5.00
"	4	J. H. Buckalew	5.00
"	5	C. J. Clifford	5.00
"	5	B. M. Boldridge	5.00
"	6	Joseph Townsend	5.00
"	6	Thomas Walsh	5.00
"	6	John C. Glass	5.00
"	6	W. E. Killen	5.00
"	8	Clem Hackney	5.00
"	8	James Collinson	5.00
"	8	M. J. Rogers	5.00
"	10	Lewis Kistler	5.00
"	12	W. L. Tracy	10.00
"	15	W. A. Meagher	5.00
"	15	Reuben Wells	5.00
"	15	S. L. Bean	5.00
"	15	J. M. Wallis	5.00
"	17	I. M. Malone	5.00
"	17	William McIntosh	5.00
"	17	A. Beckert	5.00
"	17	F. L. Bates	5.00
"	18	Oscar Antz	5.00
"	19	R. L. Herbert	5.00
"	23	A. S. Grant	5.00
"	23	F. W. Twombly	5.00
"	26	A. E. Manchester	5.00
"	27	John Player	5.00
"	27	T. McNabb	5.00
"	30	Luis Greaven	5.00
Feb.	2	M. T. Carson	5.00
		Carried forward...	$2,100.00

		Brought forward...	$2,100.00
Feb.	2	I. Bond	5.00
"	5	A. J. Humphrey	5.00
"	5	H. Stillman	5.00
"	8	John Kirk	10.00
"	8	H. C. Bocquet	5.00
"	9	John H. Vought	5.00
"	10	G. S. McKee	10.00
"	10	A. E. Tremp	5.00
"	12	A. H. Watts	10.00
"	12	D. O. Shaver	5.00
"	13	Peter C. Rusch	5.00
"	12	Frank Slater	5.00
"	13	T. E. Adams	5.00
"	13	J. O. Bradeen	5.00
"	13	W. P. Orland	5.00
"	14	D. D. Briggs	5.00
"	14	F. F. Gaines	5.00
"	14	E. M. Lake	5.00
"	15	J. J. Casey	5.00
"	15	C. M. Taylor	5.00
"	15	John Hawthorne	5.00
"	15	E. T. James	5.00
"	15	J. Potton	5.00
"	15	H. T. Peyton	5.00
"	15	A. M. White	5.00
"	16	B. Sinnott	5.00
"	16	C. E. Fuller	5.00
"	16	F. W. Mahl	5.00
"	16	A. L. Studer	5.00
"	17	F. B. Smith	5.00
"	17	Geo. Thompson	5.00
"	17	A. S. Vogt	5.00
"	17	A. W. Gibbs	5.00
"	19	C. J. McMasters	5.00
"	19	Z. T. Brantner	10.00
"	19	A. F. Stewart	10.00
"	19	Jacob Christopher	5.00
"	19	G. W. Kenney	5.00
"	19	W. A. Foster	5.00
"	19	G. R. Garrick	10.00
"	19	J. C. Shields	5.00
"	21	John Foulk	5.00
"	21	T. B. Purvis, Jr	5.00
"	21	R. English	5.00
		Carried forward...	$2,350.00

		Brought forward...	$2,350.00
Feb.	20	T. A. Foque	5.00
"	22	F. W. Morse	5.00
"	22	George W. Smith	5.00
"	23	G. A. Ferguson	5.00
"	26	G. S. Mackinnon	5.00
"	26	E. E. Hudson	5.00
"	26	J. W. Hall	5.00
"	26	H. C. Smith	5.00
"	27	G. L. Romans	5.00
Mar.	1	J. S. Patterson	5.00
"	1	F. N. Risteen	5.00
"	3	J. M. Coale	10.00
"	3	H. M. Minto	5.00
"	6	F. G. Lauer	5.00
"	6	William Hassman	5.00
"	6	C. F. Street	5.00
"	9	P. H. Brangs	5.00
"	9	E. Barrington	5.00
"	9	W. I. Cooke	5.00
"	10	John Howard	5.00
"	10	J. E. Irwin	5.00
"	12	Edwin Priest	10.00
"	12	G. R. Joughins	5.00
"	21	H. G. Hudson	5.00
"	21	W. D. Holland	5.00
"	23	Charles Robkin	5.00
"	28	Joseph Billingham	5.00
Apr.	2	William Kelly	5.00
"	4	R. Tawse	5.00
"	5	E. T. White	5.00
"	6	Robert Gould	5.00
"	6	L. S. Randolph	5.00
"	7	W. A. Smith	5.00
"	9	R. E. French	5.00
"	9	James T. Gordon	5.00
"	12	C. T. McElvaney	5.00
"	14	T. L. Chubb	10.00
"	18	C. A. Ward	5.00
"	18	John L. Smith	5.00
"	18	R. L. Ettinger	5.00
"	18	Jas. McDonough	5.00
"	20	A. W. Greenwood	5.00
"	20	James M. Dow	5.00
"	23	L. R. Johnson	5.00
		Carried forward...	$2,585.00

	Brought forward...	$2,585.00
Apr. 26	H. P. Robinson..	10.00
" 26	E. W. Jerome....	5.00
May 3	H. G. Bechhold..	5.00
" 3	M. K. Barnum ...	5.00
" 3	George C. Morton	5.00
" 4	G. E. Van Brunt.	5.00
" 7	J. N. Sanborn....	10.00
" 9	William Lachlan .	5.00
" 9	A. T. West	5.00
" 11	James Hardie....	10.00
" 11	W. I. Cooke	5.00
" 11	Charles Blackwell	5.00
" 14	S. A. Steele......	10.00
" 14	H. Tandy........	5.00
" 14	George Lindoff...	10.00
" 17	T. B. Purves, Jr..	5.00
" 17	C. F. Ward......	10.00
" 18	James Carr	5.00
" 19	H. Pearse........	5.00
	Carried forward...	$2,710.00

	Brought forward...	$2,710.00
May 22	M. D. Brown	5.00
" 23	George A. Bruce.	10.00
" 23	F. C. York	5.00
" 25	W. T. Thompson	10.00
" 25	J. R. Bisset	5.00
" 28	Charles Linstrom.	5.00
" 29	J. F. Deems......	5.00
" 31	J. P. Bay	10.00
" 31	James Kennedy ..	5.00
June 5	A. L. Beattie.....	5.00
" 5	T. F. Rotheram..	5.00
" 5	L. C. Todd	5.00
" 5	T. J. Hatswell....	10.00
" 5	W. Montgomery .	10.00
" 5	Patrick Ryan.....	5.00
" 7	H. A. Gillis......	5.00
" 5	George H. Shone	10.00
" 7	Thomas Paxton..	5.00
" 7	T. G. Brownell...	5.00
	Total	$2,835.00

THE SECRETARY: Since the above report was written, I have been advised by the Stevens Institute authorities that the spring competitive examinations were held the first week in June, but that no applications were made for the Association scholarship now vacant. This being the case, in accordance with the provisions of the constitution, an opportunity will now be given to other railroad employes, or the sons of other railroad employes (preference being given to employes, the sons of employes or sons of deceased employes of the mechanical department) to enter the competitive examinations to be held in September next for this vacant scholarship, and notice will be sent to the members of the Association in a short time.

THE PRESIDENT: Gentlemen, what action will you take on the report of the Secretary? I will say that it has been presented to the Executive Committee and has passed through their careful consideration. What is your action?

MR. PETER H. PECK: I move that it be received and adopted.

Carried.

THE PRESIDENT: We will now listen, gentlemen, and be favored with the report of the Treasurer.

The Treasurer, Mr. George W. West, presented the following report:

SARATOGA SPRINGS, N. Y., June 20, 1900.

To the Officers and Members of the
American Railway Master Mechanics' Association:

GENTLEMEN,—There was turned over to me on October 10, 1899, $3,116.94, on which there was an exchange charge of $3.20, leaving a balance of $3,113.74 to the credit of the Association on that date. On June 16, 1900, an additional amount of $291.10 was added to this credit, and the interest on the original deposit, $63.79, added to the account, leaves a balance to the credit of the Association, which is now placed in the First National Bank of Middletown, N. Y., $3,468.63.

GEO. W. WEST,
Treasurer.

THE PRESIDENT: Gentlemen, while the Executive Committee has not counted the money, it has every reason to believe that the report of the Treasurer is correct. What is your pleasure?

MR. GARSTANG: I move that it be received and adopted.

The motion was carried.

THE PRESIDENT: Gentlemen, at a meeting of the Executive Committee held last evening, it was decided that the annual dues should remain the same as last year, $5.

Gentlemen, it is necessary at this stage of the proceedings to elect an Auditing Committee. I would therefore be glad to have you make nominations.

MR. H. A. GILLIS: I move that the President appoint that committee.

THE PRESIDENT: Gentlemen, it is my impression that it has been customary for the Association to elect the Auditing Committee and I would suggest that you continue the same practice.

MR. ANGUS SINCLAIR: Mr. President, it is distinctly required by the constitution that the Auditing Committee be elected, and without nominations, by ballot.

MR. JOHN MACKENZIE: And by ballot; that is right.

THE SECRETARY: The constitution says, in regard to the Auditing Committee:

> At the first session of the annual meeting, an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for.

Mr. Mackenzie: I nominate Mr. Pomeroy.

Mr. Garstang: I nominate Mr. T. A. Lawes.

Mr. G. R. Henderson: I nominate Mr. Peter H. Peck.

Mr. F. A. Delano: I move that the nominations be closed.

The President: It is moved and seconded that the nominations be closed. The nominations consist of Messrs. Pomeroy, Peck and Lawes.

Mr. Sinclair: I move that the Secretary be instructed to cast the ballot for the nominations. (Seconded.)

The President: It has been moved and seconded that the Secretary be instructed to cast the ballot for the three gentlemen nominated for the Auditing Committee.

The motion was carried.

The Secretary: I cast the vote for Mr. Pomeroy, Mr. Lawes and Mr. Peck, and would say that the papers are ready for examination and will be handed to the committee at the end of this session.

The President: Gentlemen, you have by the action of the Secretary elected Messrs. Pomeroy, Lawes and Peck as the Auditing Committee.

Mr. Secretary, have you any unfinished business?

The Secretary: I have no unfinished business, Mr. President.

The President: Any new business?

The Secretary: Mr. President, I have the following notice:

We hereby propose the name of Francis W. Lane, Mechanical Editor of the *Railway Age,* for associate membership in the Master Mechanics' Association.

J. H. McConnell,
W. S. Morris,
George W. West,
A. M. Waitt.

Mr. Angus Sinclair: Mr. President, I propose Henry Elliott, J. I. Greatsinger and Robert Miller for election as honorary members of this Association. Mr. Elliott is one of the oldest members of the Association, having joined in 1869, really the first active year of its history. The others are not so old, but they are both out of mechanical railway service for good, and it is usual to extend that honor to gentlemen who have gone through the heat and fight of the day as active members and then go out of active railway service.

THE PRESIDENT: Gentlemen, the selection of an associate member will be referred to a special committee to report at the next convention. The election of honorary members is done by the Association in convention.

MR. G. R. HENDERSON: Is there not a limit to the number of honorary members? I thought we had nearly filled up the list that we were allowed by our constitution.

THE PRESIDENT: There is one vacancy in the associate membership. There is no limit to the number of honorary members.

MR. MACKENZIE: May I ask what order of business we are operating under?

THE PRESIDENT: Under the head of new business.

MR. MACKENZIE: Is there anything before the house? If not, I would like to make a motion. I understand from the Secretary that there is one scholarship in Stevens Institute that is not filled and that there are no applicants. Now, it seems to me as long as we own that scholarship we ought to have it filled. It is to the advantage of the Association to have it so and I move you, sir, that when we can not fill a position from railroad operatives that we extend the scholarship to the locomotive works.

MR. SINCLAIR: I second it.

THE PRESIDENT: Gentlemen, you have heard the motion of Mr. Mackenzie. Are you ready for the question? The motion is to the effect that where the Association has no scholar to propose that the locomotive works of the country be afforded that opportunity. Is that it?

MR. MACKENZIE: Yes, sir.

THE SECRETARY: First, these scholarships are open to the members, sons of members or sons of deceased members of the Association, and then if at the June examination there is no one to fill the position, it is thrown open to the other departments, preference being given to the mechanical departments. Now, you want to extend it to the locomotive works.

Mr. Mackenzie: Yes, sir.

The President: Mr. Mackenzie, I will have to ask your indulgence a few moments. I will appoint on the committee on the application of Mr. Lane for associate membership, Mr. Mackenzie, Mr. Quayle and Mr. Garstang.

There is a question which had slipped my mind, and that is on the election of the honorary members proposed by Mr. Sinclair. That matter is before the Association for their action.

Mr. Miller: In connection with Mr. Mackenzie's motion, I would like to ask if it would be practicable or for the benefit of the Association to transfer two of those scholarships from their present location to Purdue University.

The President: If the gentlemen will excuse a slip on my part, I would like to take up first the question of Mr. Sinclair's proposition, which is now before the house, on the election of the honorary members.

Mr. W. H. Marshall: I move that the proposal to elect honorary members be referred to the Executive Committee for its consideration and recommendation at a later session of this convention. (Seconded.)

The President: The question is on referring of the election of these gentlemen to the Executive Committee for its consideration and recommendation. As many as favor the motion signify it by saying " aye"; contrary " no." The motion is carried. It is referred to the Executive Committee.

The President: The question now before the house is on the adoption of Mr. Mackenzie's motion.

Mr. Mackenzie: Mr. Chairman, I withdraw my motion, with the consent of the second.

The President: There is nothing before the house at the present time.

The Secretary: I have the following notice that was handed in this morning:

> Members of the Association who wish transportation to Boston by way of the Fitchburg Railroad will be furnished with same by applying to J. F. Turner, 451 United States Hotel.

Under date of August 29, 1899, I received the following letter from Mr. Frederick B. Miles, of Bement, Miles & Co., Philadelphia, Pa.:

PHILADELPHIA, August 29, 1899.

Mr. Jos. W. Taylor, American Railway Master Mechanics' Association, Rookery, Chicago:

DEAR SIR,—Enclosed please find $5 to pay my dues for 1899. I would, at the same time, authorize you to hand in my resignation as a member of the Association. I do this because I have reached the age of retiring, and am about to retire from business permanently.

Very truly yours,
FREDERICK B. MILES.

This letter was considered by the Executive Committee last night and it recommends that Mr. Miles be made an honorary member of this Association. He joined in 1871.

THE PRESIDENT: Gentlemen, this communication has been referred by the Executive Committee to the Association.

MR. MILLER: I move that the recommendation of the committee be laid on the table for the present, to be taken up again when the Executive Committee has reported its recommendations regarding honorary membership.

The motion was carried.

THE SECRETARY: Mr. President, I have the following letter from the National Railway Blacksmiths' Association:

LIMA, OHIO, June 18, 1900.

To the American Railway Master Mechanics' Association, in Convention Assembled, at Saratoga, N. Y.:

GENTLEMEN,— On behalf of the National Railway Master Blacksmiths' Association, I beg to express to your honorable body the deepest gratitude of this organization for the action taken by you at your last meeting and for the coöperation and encouragement throughout the year, which has resulted in a very natural gain in our membership as well as a deepening of interest in those already in the work.

We also extend to as many of you as can see your way clear to do so a most cordial invitation to be present at the next meeting of this Association, which will convene at the Cadillac Hotel, Detroit, Michigan, September 18, 1900.

Very respectfully yours,
A. L. WOODWORTH,
Secretary.

THE PRESIDENT: Gentlemen, what is your pleasure with this communication?

MR. MACKENZIE: I move that it be received and referred to the Executive Committee. (Seconded.)

THE PRESIDENT: It has been moved and seconded that it be received and referred to the Executive Committee. All in favor of the motion will signify by saying "aye"; opposed "no."

The motion was carried.

THE SECRETARY: If any members desiring New York Central transportation will apply to Mr. Waitt at any time before 4 o'clock today it will be sent for and furnished.

THE PRESIDENT: Have any of the members anything to bring up under the head of new business?

The next order of business is the appointment of a Committee on Correspondence and Resolution. Gentlemen, what is your pleasure?

MR. GARSTANG: Mr. President, I would like to ask if it is constitutional for the Chair to nominate that committee?

THE PRESIDENT: I am satisfied, Mr. Garstang, that it would avoid considerable confusion and expedite the business of the Association to have the Chair do that.

MR. GARSTANG: I make a motion to that effect.

Carried.

THE PRESIDENT: The Chair will appoint that committee a little later in the day.

The next order of business is the appointment of committees on Obituaries. That matter is also under consideration and the committees will be announced later.

The next order of business, gentlemen, is the discussion of reports. Unless there are objections raised we will take up that order of business. The first report before you this morning is on "What Can the American Railway Master Mechanics' Association Do to Increase its Usefulness?" Mr. Browne, will you please come forward.

It seems to me as practically all of the members of the Association present today have been very busy in the last four or five days and have had no opportunity to read these reports, that it would be better that Mr. Browne should read this report in its entirety.

MR. T. R. BROWNE: Your committee, in looking up this question, took pains to correspond with prominent general managers and general superintendents of various railroads in this country on purely a personal basis, and received in reply a great many valuable suggestions. The essence of these suggestions is contained in this report. There seemed to be a general expression of feeling with some of these men that the Association had a tendency to confine itself too closely to the question of the locomotive, and that it had a field outside of the locomotive, in the matter of shops and equipment incidental to its maintenance, which did not, as a general rule, come up as prominently in the Association as it might.

MR. BROWNE read the following report:

REPORT OF COMMITTEE ON "WHAT CAN THE MASTER MECHANICS' ASSOCIATION DO TO INCREASE ITS USEFULNESS?"

To the President and Members of the
American Railway Master Mechanics' Association :

Your committee desires to submit suggestions concerning what appear to be possible improvements in the methods of this Association, bearing in mind the very valuable character of the proceedings and the great importance of the organization. These suggestions are grouped under the following heads: First, Conduct of Conventions; second, Subjects and Their Presentation; and, third, The Proceedings of the Association as a Record.

(1) CONDUCT OF CONVENTIONS.

ninating nmittee.

Some time might be saved in electing officers by appointing a nominating committee early in the convention, it to report later in the convention, the election not, however, being absolutely limited to the names thus nominated. This would permit of a careful and dignified selection of officers, and it is a custom followed by many other organizations, including the Master Car Builders' Association.

nission of ociate nbers.

While the election of associate members does not come before every annual convention, considerable time is occupied in voting whenever it is necessary, and it might be well to consider the advisability of adopting the letter ballot, as is done by the American Society of Mechanical Engineers. The letter ballot has the important advantage of offering to the entire membership information concerning candidates. Voting may then be intelligent, and it will be uninfluenced by haste to proceed to other subjects.

ord Votes.

After a thorough discussion upon a question of practice, in which differences of opinion are held, it is often very important to measure the views of the members present by a record vote. Members should be able to judge from the printed proceedings as to the opinion of the majority on questions of practice. Expressions of the views of the majority of the members would be a good and safe guide of great value in railroad service, as indicating the most approved lines for future procedure. It has been suggested, in the question of cast-iron or steel-tired wheels last year, that the absence of a record vote leaves the discussion in such shape as to open the door for possible embarrassment in the event of a suit for damages arising from a broken cast-iron wheel.

Discussions.

It would facilitate the discussions desired if the President should meet all committee chairmen and authors of papers before the opening of the convention for the purpose of planning the discussion on each question.

A glance through past volumes of the proceedings shows that many facts and also clear expressions of opinions are brought out when point is given to the remarks by a resolution asking for the "sense of the convention" on the subject at hand.

The Executive Committee might help to secure lively discussions by arranging in advance for the introduction of each subject, by asking specially well informed members to prepare introductory remarks in writing. This would be further assisted by the committees if they would suggest lines for discussion of their own reports.

If, before the opening of the convention, several persons selected outside the list of committees, and of those introducing topical discussions, should be invited to take up in the discussion some phase of each of the reports, it would be possible to greatly increase the interest of the sessions by extending the feeling of responsibility among a large number of the members. Many would probably take part in the discussions in this way who would otherwise remain silent.

Selection of Committees.

The appointment of committees should be made with regard to the special qualifications of each member to treat the subject assigned him and without reference to the individuals who suggest subjects. It is now considered courtesy to appoint as chairman of the committee on that subject, the member who requests the presentation of a report.

It would seem advisable for the committee on subjects to recommend the committees, and also the chairmen, for this committee naturally knows who are best fitted to treat the subjects selected. This might be done by nomination to the President for his appointment.

Committees should be small in numbers. The best reports are usually those presented by not more than three men. A large number usually means subdivided responsibility, and generally three or less do all the work if the committee is larger than that. This applies specially to committees on subjects requiring research and experiment.

(2) SUBJECTS AND THEIR PRESENTATION.

Individual Papers.

The railroad technical organizations, so far as we know, are the only ones of their class depending so largely upon committee reports. For certain subjects requiring experiment and research this method is the best one to be used, but for other subjects, individual papers are believed to be better. Committee reports must necessarily be in committee style, without individuality. Three or more men seldom agree in their views sufficiently to permit of positive expressions of opinion such as may be had from individuals. By following the committee-report system exclusively the Association loses the benefit of descriptions of tests or other valuable work, which members might be induced to place on record in the form of papers. The proceedings of other organizations are rich in material of this kind, for which our constitution makes no provision. Some of the railroad clubs and the American Society of Mechanical Engineers have published valuable papers which might have been brought before this Association. Committees, however, should be entrusted with the most important subjects which affect the entire membership. There are always three or four of these each year which can not be treated in any other way.

tracts.

The rule for presenting long papers and reports before other national technical organizations is to present them by reading the title or a previously prepared abstract, which may be read in from five to ten minutes. If the papers and reports are distributed to the members sufficiently long before the convention, this works well, and a great deal of time is saved. It is not now considered entirely necessary to invite the author of a paper to read it himself, and it is important to have and observe a rule in this regard. The effect of the reading in full, or nearly so, of a long paper or report, is a serious one in such conventions as these. It is likely to detract from the value of all the subsequent business of that session in which it occurs. The most important points should be reviewed in the abstract.

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It was said publicly last year before another association that the railroad clubs were doing the work formerly done by the Master Mechanics' Association. Whether true or not, it is certain that the clubs may be made to serve the national organization in a very important way. It is difficult to secure expressions of opinion from the most experienced members in the discussions of the Master Mechanics' Association. Would it not be desirable to ask the clubs to assist in gathering information of this kind? Many will talk freely before their local clubs who are not willing to take part in discussions before this Association. Subjects which involve experience might be handled by a committee composed of one member from each of the clubs, a part of whose duty would be to secure the expressions of opinion in that club. Clubs are used to good effect by the Master Car Builders' Association in the matter of the interchange rules, and the views of the men who actually use the rules are obtained as they could not be by other means. The systematic assistance of the clubs might be used to great advantage in many subjects.

tructions to
nmittees.

The instructions to committees assigned to special subjects should be explicit.

It might be well to send out the instructions to each committee with a printed heading containing hints as to the best methods of presenting subjects in general. These might start with a suggestion that the report should begin with "The State of the Art," followed by reference to previous records on the subject, and after the discussion in the report the conclusions should be reviewed in a brief summary. A few suggestions as to the line of discussion desired by the committee would not be out of place as an ending of a report, and every report involving research or investigation should present the opinion of the committee, or at least the choice of opinions. Whenever it is appropriate reports should conclude with resolutions embodying the recommendations of the committee.

Subjects.

The assistance of other associations whose membership is confined to a special branch of motive-power work, such as the blacksmiths, the air-brake men, the traveling engineers and the painters, might be had and used to great advantage, perhaps by referring special questions to them for discussion and expression of opinion. This would also tend to encourage the smaller associations, and would bring out the community of interests of the associations.

Shop design is a subject always full of interest, and the arrangement of shops, shop heating, power distribution and methods of handling material might perhaps receive more attention with advantage. A great deal of information would be brought out by good papers on shop cranes, the arrangement of tracks in shops, the place of the gas engine in shop driving and the use of gas producers. These subjects would be more satisfactorily treated in individual papers than in committee reports, but they perhaps will serve to indicate a line of subjects which might profitably be undertaken. The subjects should not be confined to the locomotive, but should cover the whole work of the members and include organization and administration problems.

A member suggests the establishment of a standing committee on standard specifications and tests to prepare specifications for railroad materials with rules for inspection and test, their recommendations to be submitted to letter ballot for the endorsement of the Association.

Your committee believes that a concise report each year, embodying descriptions of the latest improvements in tools of special design for railroad shops, and made each year by a standing committee, would be of great value to the members of this Association, especially to those located at great distances from mechanical centers, and whose opportunities for personal investigation are limited, it being distinctly understood that the report of such a committee would in no sense embody advertising features, but rather be a description of the devices, and their applicability to the peculiar needs of railroad work as parts of shop equipment.

Another addition to the number of standing committees might be made in a committee which shall each year make a report covering, briefly, the progress of the year and the lessons to be derived therefrom, in connection with vital motive power questions.

Committee on Subjects.

This is one of the most important of the committees. It should be expected to assist in the actual work of the convention as well as to outline the ground to be covered.

Topical Discussions.

Topical discussions are usually very interesting and valuable in bringing out opinions and expressions of experience. They must necessarily be made to fit in among other parts of the proceedings, and they are often crowded out and omitted because of lack of time. Their presentation should be prepared in advance, and if put in writing these might be printed in the records instead of being left over for a year or lost entirely in case they are not read. These informal discussions often lead to the further pursuit of a subject in which special interest is developed, and they appear to be exceedingly important and well worthy of cultivation. More time might profitably be put into these discussions. The success of this feature of a convention depends largely upon the character of the presentation, and the members selected for this purpose should be chosen with great care.

(3) THE PROCEEDINGS AS A RECORD.

lex.

The value of a printed record of the proceedings covering more than thirty years is undoubtedly appreciated. It presents a history of motive power subjects and is growing more valuable every year. This information, however, is scattered over a great number of pages and it is not easy to find particular reports and discussions. In the nature of the work done there must necessarily be more or less repetition of subjects, and this renders it exceedingly important that previous decisions should be readily found. A complete and elaborate index of the reports from the first one is suggested. This was taken up in 1890. A great deal of very important work has been done since then, and for recent records the subsequent volumes must be searched in detail. Each committee needing such records must obtain them by a laborious process. The following suggestion on this subject has been received from one of the members:

" I beg to submit the idea of annually getting out a complete index covering all the back proceedings of the Association; this index to have papers and discussions entered under as many heads as possible, so as to facilitate the looking up of any railway mechanical subject; there is a great deal of very valuable information in reports of committees, discussions and experiments of various kinds that the older members are familiar with, but which is quite difficult for young members to find. It would be of untold advantage to me, and I have no doubt to many others, in looking up a certain subject, to be able to refer definitely to every case where the matter to be investigated had been before the Association, either in the form of a report of a committee, or a topical discussion. I think that if each year this index could be rearranged and enlarged to include the current proceedings of the Association that many of us would be very glad to assist in paying the expense of getting it up."

This, in the opinion of your committee, is one of the most important suggestions which we have to make, and one which, proportionate to the thoroughness with which this index is prepared, will make past and future proceedings available for instant reference, and as it was intended they should be. Your committee is thoroughly aware of the great labor involved, and the high degree of skill and experience required in preparing an index of this kind, and has ascertained its probable cost.

aracter of
ports.

The work of the Association must necessarily be that of investigation and dissemination of knowledge. A member, who is by the way very reliable himself, says: "The criticism I would make is that some of the reports presented to the Association are not prepared with sufficient care, and are not thoroughly reliable; the Master Mechanics' Association is by no means alone in this, however. If railroad people in general could feel that the information presented in the reports is the result of facts carefully determined under conditions comprehensively set forth, I am sure they would find the proceedings very useful."

ports and
nclusions.

It may be worth while to consider the advisability of using heavy-faced type for the most important parts of papers or committee reports and definite actions by the Association, for the purpose of increasing their convenience in reference. Final results and conclusions might be made more prominent in this way. In many reports it is necessary to search a number of pages in order to ascertain the conclusions of the committee. It would certainly add greatly to the value of the records to always have the crystallized opinion of the investigating committee plainly expressed and arranged so as to be easily found.

Library.

The printed proceedings of this Association are sought for in technical libraries, and they might be sent in exchange for technical periodicals and proceedings of other societies. In this way a valuable reference library could be assembled and in time it would be very convenient for the use of railroads desiring references to special subjects. The Western Railway Club has, in the David L. Barnes Library, a good working collection of technical literature. It is now made available to members who, by correspondence with the librarian, may secure references to any subject arising in the lines covered by the library. A similar plan or arrangement of combining a Master Mechanics' Association Library with the one referred to seems to be worth considering.

SUMMARY.

Your committee would sum up its suggestions as follows:

A nomination of officers by a nominating committee;
An improved method of admitting associate members;
The taking of record votes on questions of practice;
More preparation for the introduction of discussions, and more complete plans for their consideration;
The abolition of the universal practice of appointing as chairman of a committee the member who suggests the subject for committee investigation to the committee on subjects;
Recommendations to the president by the Committee on Subjects of members best qualified to present them;
Committees of investigation composed of small numbers of individuals;
Provision for the reception of individual papers;
Strict adherence to the rule requiring the presentation of long papers by abstract;
The co-operation of railway clubs and special organizations in the presentation of opinions on practice, and in the suggestion of subjects for investigation;
More explicit instructions to committees as to arrangement, and advancing conclusions in reports;
The appointment of several additional standing committees on subjects concerning motive power progress;
Increased responsibilities of the Committee on Subjects in the actual work of the convention;
Provision for a thorough printed index of the proceedings of the Association from the first volume;
An effort to make the reports presented to the Association thoroughly reliable;
A typographical arrangement of reports which will render the conclusions and decisions more easily found;
The establishment of a library similar in plan to that of the Western Railway Club.

CONCLUSION.

Your committee desires to propose the following resolutions:

Resolved, That a committee be appointed to consider the suggestions made in this report, and present later in this convention recommendations for such changes in the constitution as may be necessary to carry them into effect.

Also the following:

Resolved, That a committee be appointed with full authority to act in the preparation of a complete printed index of the proceedings of this Association from the first volume to date, the expense to be defrayed by the treasury, upon the approval of the Executive Committee.

T. R. BROWNE,
G. M. BASFORD,
L. R. POMEROY,
Committee.

ALTOONA,
April 11, 1900.

THE PRESIDENT: Gentlemen, what is your pleasure with the report?

MR. MORRIS: I move that the report be received and the resolutions adopted. (Seconded.)

THE PRESIDENT: Gentlemen, it has been moved and seconded that the report be received and the resolutions adopted. Are you ready for the question?

MR. WHYTE: Before adopting the second resolution, it might be well to know the cost of indexing the proceedings and whether there is money enough in the treasury to do it. The committee says that it has estimated the cost for doing that work.

THE PRESIDENT: I understand it will cost about four hundred dollars to do this.

MR. BROWNE: From four to five hundred dollars.

THE PRESIDENT: Four to five hundred dollars to compile that, aside from the printing, and we have something like $3,300 in the treasury. Are there any remarks on the subject?

MR. MILLER: Mr. President, in connection with this I would like to ask if it would be practicable to make an abridged edition of the reports of the Master Mechanics' Association for the first years of its existence, or if those reports can be procured. The younger members of the Association are without the proceedings of the convention for a large number of years.

THE SECRETARY: Mr. President, we have probably two or three tons of the back numbers of the proceedings. We are short the proceedings for the years 1873, 1874 and 1887. With the exception of these three years we have quite a large number of volumes of the previous years' proceedings.

THE PRESIDENT: As many as favor the motion that the report of the committee be received and the last two resolutions offered by the committee be adopted will please signify it by saying " aye "; contrary " no."

The motion was carried.

THE PRESIDENT: The committee on the first resolution: "That a committee be appointed to consider the suggestions made in this report and present later in this convention recommendations for such changes in the constitution as may be necessary to carry them into effect"—will consist of Mr. Quayle, Mr. Vauclain and Mr. Soule. The second resolution is: "That a committee be appointed with full authority to act in the preparation of a complete printed index of the proceedings of this Association from the first volume to date, the expense to be defrayed by the treasury upon the approval of the Executive Committee." That committee will consist of Mr. Delano, Mr. Bush and Mr. Mendenhall. I would state for the Association that Mr. Delano has done quite a good deal of work in this direction and has a large amount of matter prepared for such a report.

MR. SOULE: Mr. President, as I am compelled to leave Saratoga this afternoon and shall not be here either of the remaining days, I would ask to be relieved from membership in that committee.

THE PRESIDENT: In place of Mr. Soule I will appoint Mr. Gillis on that committee.

Gentlemen, the hour has arrived for topical discussion.

MR. GIBBS: After the regular business of this hour will this report be open for discussion?

THE PRESIDENT: My impression is that that has been disposed of, from the fact that the report has been received and resolutions adopted to appoint committees on that subject.

MR. SINCLAIR: Mr. President, receiving a report implies that it is then ready for discussion, that it is open for discussion.

THE PRESIDENT: If the Association wishes to discuss the question of the report of the committee there are no objections; but the noon hour has arrived and the time for taking up the next order of business is in order, unless the Association sees fit to order it otherwise.

MR. GILLIS: There are one or two matters in the report that I would like to discuss, and possibly there are other members who would like to say something. I would make a motion that the report be discussed for ten minutes. (Seconded.)

The motion was carried.

Mr. Gillis: Mr. President, I think this report on the general conduct of the Association is one of the best and most helpful reports that we have had. I notice that the committee recommends the taking of a letter ballot on associate members. I would like to see honorary members balloted for in the same way. I want to endorse Mr. Miller's suggestion as to the reprinting or revising of the proceedings. Several years ago the Norfolk & Western road had considerable difficulty in obtaining a full set of the proceedings of the Master Mechanics' Association, and the Richmond Locomotive Works is at present without a full set of the proceedings, and I feel sure that a large number of individuals, societies and railroad companies would be glad to have a full set of proceedings. The American Society of Mechanical Engineers reprinted all their proceedings about eight or nine years ago, giving the membership of the society an opportunity to subscribe in advance, and a large number of them availed themselves of the privilege. I would offer this resolution:

> *Resolved,* That a circular of inquiry be sent to the members of the Association to ascertain how many of the members would subscribe for a complete set of the proceedings.

The President: Mr. Gillis, I would state that you are a member of that committee to consider the suggestions made in the report and present recommendations to the Association for such changes in the Constitution as may be necessary to carry them into effect.

Mr. J. F. Deems: There is one point in this report that I would like to say just a word about. It is on the second page:

> The Executive Committee might help to secure lively discussions by arranging in advance for the introduction of each subject by asking specially well-informed members to prepare introductory remarks in writing.

Now I believe the reason the different railway clubs have succeeded in preëmpting, I might say, the work of this Association in some instances, and why they have done such valuable work, is the very fact that some of them do that. When a subject is to be brought up members are selected and requested to come prepared to discuss that subject. I hope the committee that has this in charge will give attention to that point. I believe there is not a member here but deplores the dearth of active discussion of some of the questions. It is not so with all of them, but with many of them it is a fact. It seems to me that that is one of the most important recommendations or suggestions—I believe it comes later on as a recommendation—in connection with the committee's work.

I was specially pleased with what Mr. Browne said in regard to many of the members confining their entire attention to the mere question of the locomotive. About two years ago I heard a prominent superintendent of motive power say that if he had his way he would not want a master mechanic on the road that had a mechanical idea in his head. Now he overstated that, intentionally no doubt, but what he wanted to convey was the idea that master mechanics were prone to give too much attention to the locomotive and not enough to the other details of their work, and I think what Mr. Browne said on that point is very pertinent indeed, and the references in the paper to details of shop work, etc., are worthy of much thought.

THE PRESIDENT: It seems that this organization of master mechanics is an exceedingly modest body. As a rule, when members of the organization get into the railway clubs, they discuss these questions very freely with one another, but when they come to the convention their modesty as a rule prevents their making any remarks on important subjects.

MR. HENDERSON: Mr. President, this report shows so much work and so much good work that I think we ought not to pass it without a little further discussion, and I would like to second the idea suggested by Mr. Gillis that honorary members also be elected by letter ballot along with associate members.

The question just referred to about having parties selected beforehand to open discussion, mentioned by Mr. Deems, is also a recommendation that should be fully considered.

In regard to reading by abstract I think that a good deal of time could be saved, particularly if the papers were sent out a little earlier. This year I received them only a few days ago. If they could be sent out two or three weeks in advance I think we could save valuable time at the meetings by reading the papers in abstract. The chairman of the committee spoke of a standing committee on test of materials, and my attention has been called to the fact that in the American section of the International Association for Testing Materials this organization could be represented by this committee, if necessary, by the payment of a small fee; I think it is $2.50. If this standing committee is appointed it might be well for them to represent this Association in the American section of the International Association for Testing Materials. I think that is a point that the committee might bear in mind when they are looking up this question that is referred to on page 4 of this report. In regard to the question of printing certain parts of the report in heavy type, I would like to say that that is something I have advocated, and I think that a great deal of valuable time could be saved in looking for data, especially in looking through papers quickly. If the important points in each report were printed in heavy type the heavy type would catch the eye quickly, without taking our time to look through the whole paper.

MR. VAUCLAIN: I do not like to differ from Mr. Henderson, but I wish to compliment the Secretary on the admirable manner in which the reports were sent out this year. I received my report quite a while ago, and as my name commenced with a V, if they were sent out in accordance with the alphabet, mine were among the last sent out. I think that sufficient time was given for a careful reading of all the reports; at least I was able to read them all carefully; and so far as the question which is raised by Mr. Gillis and afterward seconded by Mr. Henderson, the committee appointed have it in their power to make the proper recommendation to cover that point. I think it useless to waste our noon hour discussion in further discussing this report. I therefore move that the discussion close. (Seconded.)

Carried.

THE PRESIDENT: If there are no objections we will proceed to the topical discussion of nickel steel. The topic is "Nickel Steel as a Journal Bearing. Is there any Noticeable Increase in Friction and Wear as Compared with the Ordinary Steel or Iron?" The discussion is to be opened by Mr. W. H. Lewis.

Mr. W. H. Lewis: Mr. Chairman, I must say that I was considerably surprised to see that I had been selected to open the discussion on nickel steel, and when I explain to you gentlemen that the use of nickel steel on our road has been to only a very limited extent and covering a period of only about a year, you will realize how little I will have to say about it. As you know, we have had somewhat disappointing experiences with low-carbon steel, and we have gone to the other extreme as far as we thought it was safe. We have used a steel for driving axles and piston rods that was up as high as .40 to .45 in carbon. The well-known toughness of nickel steel and its selection for armor plates has prompted the belief that it might be a more suitable material for driving axles. As I read the subject, I am expected to say what my opinion of it is, particularly as a bearing metal, and if I have noticed any increase in the friction or wear. The best evidence of whether a metal is a good bearing metal is in the fact whether it will take a high polish in service, and I want to say that after little more than a year's experience with nickel steel, there is nothing that I have discovered that will lead me to believe that it is not a good bearing metal or that there is any excess of friction. I am certainly very sorry that my experience has been so limited with it and I hope that some other members who may have had more experience with nickel steel can enlighten the Association more than I can.

The President: This subject is open for discussion. We would like to hear from any of the other members present. Mr. Vauclain, can you give us any information on the subject?

Mr. Vauclain: Mr. President, I regret very much that I am unable to give you any experience in the use of nickel steel on locomotives. My business is entirely confined to the building of new locomotives and not maintaining them after they have been put in service. I might, however, enlighten the members of the convention somewhat upon the character of nickel steel as it appears during the course of locomotive manufacturing. It is my belief that nickel steel, if properly made, is a very good material and probably the best material in the line of steel that can be used. But I would caution the members to be careful as to the exact quality of the material which they may purchase and which is sold to them as nickel steel. We have found that a great amount of it is somewhat imperfect. The surface is full of very small seams running longitudinally with the material and causing quite a number of rejections. This was especially true in the early days of nickel steel. When we first commenced to use it considerable controversy and research was had in the matter and considerable improvement has been made in the forgings that have been supplied to us as nickel-steel forgings. I wish to say for the benefit of those present that nearly, if not quite all, of the forgings now shipped to us for locomotives we have under construction seems to be perfect—almost perfect—in that respect, and rejections are very few. I can see no reason, for those who are inclined to pay the extra price for nickel steel, why it should not be used in the construction of high-class locomotives. It is certainly stronger for the same weight of material used, and with that in view engineers will certainly have recourse to it for modern types of locomotives.

MR. QUAYLE: I think, Mr. Chairman, what was intended to have been brought out by this discussion was as to whether the members of the Association found any difficulty with this steel through heating; if it generated more heat than the ordinary carbon steel. I must say that we have some locomotives thus equipped and we found one or two of our locomotives with the nickel steel driving axles heating, but we do not know whether it is due to the steel or whether it is due to some local cause. You often find a locomotive fitted up in the shop with an ordinary steel or even an iron axle; some particular engine or engines may go out and run warm and continue to run warm, while other engines run perfectly cool. Some people to whom I have talked have concluded that nickel steel does develop more heat than the other steel. I learned only the other day, however, that some road had been using nickel steel rails on curves, and they found that the nickel steel rail was so slippery that they had to take it out and introduce the other steel, which would indicate that it was smooth, and the smoothness of it of course would indicate to our minds again that there would be less friction and less generation of heat. I did not know but that some of our people had some experience showing whether there was anything in that or not. We have not anything we can tie to and have found no absolute trouble from the use of nickel steel at all.

MR. GILLIS: I have had no experience personally with nickel steel, but I do know that the Government is using nickel steel to a very large extent in marine engines and in such service as torpedo boats and destroyers, the engines of which are run at very high speed, as you know, and under conditions which necessarily require that the very best material and the material which will give the least trouble from heating must be used. Considerable experimenting has been done and I think the department of engineering of the navy has almost considered it beyond experiment and it is a standard metal for service in marine engines.

MR. DELANO: Mr. Chairman, it seems to me that in Mr. Lewis' remarks there was a little confusion as between the bearing metal and the metal borne. While I can see that Mr. Lewis is probably right, that for the metal borne the best metal is probably the one which will take the highest polish, I question very much, from information I have been able to get, that the best bearing metal is the metal which takes the highest polish, or which is the most homogeneous, or which is the most dense. There seems to be very strong evidence that a good bearing metal must be somewhat porous, that it must be crystalline, must have crystals of different structure imbedded in it, and that a homogeneous bearing metal of close texture which will take a high polish will not make a good bearing metal.

COL. H. G. PROUT: Mr. President, I have no right to speak on this floor, but I would like to say one word to correct an error. Mr. Quayle mentioned the fact that certain nickel steel rails had been replaced because of diminished adhesion due to the polish of the surface. That statement has had wide circulation in the newspapers, but it is entirely untrue. Those nickel steel rails have not been taken out of the track, nor has it been discovered that there was any less adhesion to those rails than to the ordinary carbon steel rail.

MR. L. R. POMEROY: Mr. President, I think that a great many people have looked upon nickel steel with very great favor because of the published results in connection with its use in the navy, and I think that the reason why a great many persons have been disappointed in the use of the nickel steel that they have tried has been because they have not had the same quality, or the steel has not been subjected to the same treatment as the steel which they have been reading about and formed the basis of their desire to make a trial. There is nickel steel and nickel steel, the same as there is iron and iron.

THE PRESIDENT: Are there any other remarks to be made on nickel steel? If not, we will proceed to the consideration of the report on the extent to which the recommendations of the Association have been put into practice. Mr. Delano is chairman of that committee. While the reports are being distributed, the Secretary will read an announcement.

THE SECRETARY: Members of the Master Mechanics' Association desiring return Pullman transportation can obtain the same from H. M. Pflager, Mechanical Superintendent of the Pullman Company, Room 437, Grand Union Hotel, until Friday night.

THE PRESIDENT: I suppose, gentlemen, that all of you will accept Mr. Pflager's kind invitation.

The Secretary will now read the list of Committees on Obituaries.

THE SECRETARY: Mr. W. C. Arp is appointed committee on John Torrance; Mr. J. N. Barr, on W. H. Harrison; Mr. W. E. Symons, on J. B. Glover; Mr. Charles Linstrom, on J. G. Tomlinson; Mr. Pulaski Leeds, on James Cullen; Mr. Willard Kells, on Thomas Carmody; Mr. W. H. Lewis, on J. E. Battye; Mr. T. B. Purves, on W. H. Stearns; Mr. Washington Lavery, on George B. Ross.

THE PRESIDENT: We will now proceed with the consideration of the report on "The Extent to Which the Recommendations of the Association Have Been Put Into Practice."

Mr. Delano presented the following report:

ALPHABETICAL INDEX

AND

CLASSIFIED INDEX

OF

SUBJECTS OF REPORTS, PAPERS AND DISCUSSIONS

(NOTE.—Topical Discussions will be indicated by the letter T before the date of report referred to.)

Prepared by MR. FRANK ZELENY, M. E. (Univ. of Minn.)
of Aurora, Illinois,

AT THE DIRECTION OF THE

Committee appointed by the Convention in June, 1899, to ascertain "to what extent the recommendations of the American Railway Master Mechanics' Association were being put into practice."

F. A. DELANO,
A. SINCLAIR,
H. MIDDLETON,
Committee.

ALPHABETICAL
INDEX OF SUBJECTS OF REPORTS, PAPERS AND DISCUSSIONS.

A.

Annealing, boiler sheets, T 1880, 31-32.
Apprentices, 1896, 282-302; 1897, 166-187; special, T 1898, 99-103; 1898, 233-252.
Ash-pans (see also Grates and Ash-pans):
  Prevention of escape of live coals and sparks, 15 drawings, 1888, 126-132.
  Self-dumping, T 1886, 23.
Axles:
  Steel tires, wheels and axles, 1869, 41-55; 1870, 58-85; 1871, 46-60; 1873, 176-191.
  Best shape of axles for cars and locomotives, compound axles and loose wheels, 1873, 135-172.
  Standard, 1874, 223-239; 1875, 161-172, 188-199. M. C. B. standard adopted, 1879, 14-35, 52-58.
  Tests, 1875, 184-188.
  Best form and material for locomotive wheels and axles, 1878, 20-50; 1879, 45-52.
  For heavy tenders, T 1889, 91-102; adopted, 1890, 159-167; 1899, 295.
  Relative value of steel and iron, 1890, 109-127; 1891, 48-63.

B.

Boiler sheets, annealing. See Annealing.
Boilers, locomotive, 1869, 21-31; 1875, 15-48, 79-103; 1878, 65-110; 1879, 59-107; 1880, 14-17.
  Belpaire. See Boilers, Types.
  Boilers and boiler material, 1870, 12-21; 1871, 10-20; 1872, 13-62.
  Best material, form and proportions, 1876, 52-118; 1877, 51-98, 113-134.
  Construction, 1885, 33-47, 63-76.
  Explosions, 1869, 55-65; 1870, 87-97; 1871, 32-37; 1872, 176, 193-199.
  Fastenings, 1898, 160-187.
  Feed-water. See also Boilers, Incrustation.
    Machinery for supplying, to tanks, 1875, 142 155.
    Best point to introduce, 1877, 135.
    Heaters, T 1888, 161.
    Heating and difficulties, T 1899, 277-280.
  Fire-boxes:
    Construction, 1870, 44-49; 1871, 60-63; 1876, 52-118; 1877, 51-98, 113-134.
    Above frames, 1890, 96-109.
    Dead plates, 1878, 118.
    Sling stays, necessity of, T 1880, 73-74.
    Strong's corrugated, 1882, 106.
    Securing crown sheet, T 1888, 32.
    Water space around, T 1888, 163; 1889, 132-143.
    Mud ring, 1889, 102-112, 127-132.
    Causes of bulging of sheets, 1895, 71-98.
    Cracking of sheets, T 1877, 222.
    Fusible plugs, use of, T 1899, 150-153.
    Baffle-plates in, 1877, 152-192.

Boilers, locomotive (*continued*):
- Flues and flue sheets:
  - Copper and iron, 1870, 104-107.
  - Welding, best method, T 1882, 68-71.
  - Removing, cleaning, resetting, 1886, 136-152.
  - Water space between, 1889, 132-143.
  - Cracking of back flue sheets, 1894, 25-56.
  - Flue area. See BOILERS, PROPORTIONS.
  - Standard specifications for iron tubes, 1895, 99-105, 123-127; 1899, 296.
  - Computing tube-heating surface, paper, 1895, 272-274.
  - Standard size of flues, 1896, 331-333.
- Heating surface. See BOILERS, PROPORTIONS.
- High boiler, effect on lateral wear of boxes, T 1888, 28, 29.
- High pressure, 1892, 149-168.
- Improvements, 1882, 12-24, 33-55; 1883, 64-89, 16 plates; 1886, 41-79; 1884, 27-75, 12 plates.
- Incrustation and water purification:
  - Incrustation, 1869, 67-69; 1870, 36-38; 1871, 20-32; 1872, 137-160; 1877, 135-152.
  - Purification, 1872, 90-95; 1873, 11-28; 1874, 20-53, 119-165; 1875, 48-72; 1891, 119-125.
  - Methods to prevent trouble from impurities, 1899, 93-124.
  - Washing, 1887, 125-133; T 1893, 192-194.
  - Use of marine salinometer to determine concentration of alkali water, T 1899, 148-150.
- Jackets, planished vs. common, 1897, 234-241.
- Lagging, 1889, 54-66; 1898, 87-99; sides of fire-box and boiler-head, drawings, 1885, 106; T 1881, 88.
- Operation and management, 1874, 20-53, 119-165; T 1878, 63-65; 1875, 15-48.
- Proportions, heating surface, grate area, etc.
  - Water surface and steam space to heating surface, 1871, 86-88.
  - Relative proportions of cylinder and driving wheels to boilers, 1888, 19-27.
  - Best proportion of grate and flue area, 1889, 112-127.
  - Ratio of heating surface and grate area to cylinder volume, 1897, 218-234.
  - Radial stay. See BOILERS, TYPES.
- Safety attachments, paper, 1881, 120-129; paper, 1882, 74-80; 1886, 33; 1893, 149-164.
- Stay-bolts:
  - Broken, T 1897, 200-203.
  - Best method of applying, 1899, 185-202.
  - Inspection. T 1893, 195-201.
- Steam space. See BOILERS, PROPORTIONS.
- Steel:
  - Paper, 1888, 171-177.
  - Flanging steel at other than red heat, T 1891, 24-29.
  - Annealing, T 1880, 31, 32.
  - Specifications for boiler and fire-box steel, adopted, 1894, 68-92.
  - Variation of ultimate strength and elastic limit with temperature, and relation between temperatures on fire and water sides, curves, 1895, 75.
- Straight top. See BOILERS, TYPES.
- Testing, T 1878, 213-216; 1885, 138-144.
- Tubes and tube sheets. See BOILERS, FLUES AND FLUE SHEETS.
- Types:
  - Relative merit of straight and wagon top, 1872, 62-78.
  - Radial stay, 1880, 50-68; 1881, 28-33, 44-50; T 1896, 265-280.
  - Belpaire, 1882, 12-24, 33-55. See BOILERS.
  - Wagon top. See BOILERS, TYPES.
  - Washing. See BOILERS, INCRUSTATION.

Bolts, fitting, paper on standard reamers and ring gauges, 1883, 221-232; T 1890, 28-32; 1892, 135.

Boxes, driving and truck:
- Brasses, securing of, 1872, 188-193.

Boxes, driving and truck (*continued*):
- Bearings, best metal for locomotive and tender, 1876, 20-31; 1885, 115-127.
- Standard journal box, bearing and pedestal, adopted, 1881, 110-115.
- Lateral wear of boxes and high boiler, T 1888, 28.
- Driving and engine truck, 1889, 37-53.
- Water on bearing surfaces, T 1897, 192-195.

Brakes:
- Braking on rail, 1870, 119.
- Application of compressed brake, 1871, 71-72; 1872, 113-133.
- Continuous train brakes, 1873, 48-56; 1874, 244-278; 1875, 125-140.
- Driving-wheel, 1886, 95-115; 1889, 66-91.
- Air-brake and signal instructions, 1891, 163-192; 1892, 168-196; 1897, 274-298; 1898, 201-233, revised.
- Air-brake instructors, their sphere, T 1899, 66-71.
- Double-headers, T 1899, 71-73.

Brasses and Bearings. See Boxes.

Brick arch, T 1877, 102; 1888, 35-78; 1890, 141-154. See Boilers.

C.

Capital and labor, paper, 1878, 200-213.

Case-hardening. See Steel and Iron.

Color-blindness. See Signals.

Combustion and smoke prevention (see Fuel, Grates, Exhaust Pipes):
- Combustion, paper, 1870, 49-55; paper, 1886, 158; best means of producing better, 1881, 52-66.
- Smoke prevention, 1880, 37-49, 69-71; 1893, 184-192.
- Steam jet in fire-box, test of, paper, 1884, 44-49.

Compound locomotives. See Locomotives.

Counterbalancing, 1878, 20-50.
- Hammer-blow, 1886, 155-158.
- Effect on wear of driving tires, 1895, 228-271.
- Rules and methods, 1896, 148-161; 1897, 117-123.

Crossheads and guides, 1888, 78-97.
- Dean dust-proof, 1885, 107.
- Reciprocating parts, 1896, 202-229.

Cylinders:
- Clearance and compression, paper, 1881, 116-120.
- Proportion of, formulæ 1887, 36-50.
- Burst steam chests, T 1889, 18-24.
- Broken, T 1893, 61-63.
- Bushing, 1896, 229-245.
- Clearance, large, uneconomical, T 1897, 188-190.
- Irregular wear with high pressure, T 1897, 197-199.
- Best metal for, 1897, 203-218.
- Ratio of heating surface and grate area to cylinder volume, and ratio of size of cylinder and length of steam port, 1897, 218-234.
- Lagging, 1898, 87-99.
- Lubrication, T 1882, 144.
- Fastening, 1898, 150-187.
- Relief valve and by-pass valve, T 1899, 273-276.

D.

Disinfectants, paper, 1887, 149.

E.

Electricity (see Shop, Motors), application to steam railroads, papers, 1897, 298-304; 1898, 194-198.

Engineers and firemen:
  Uniform system of examination for promotion, and grades of, 1872, 178-188; examination, 1891, 126-132.
  Premiums, 1883, 44-64.
  Education, 1884, 95-106.
  Watches, magnetic influence of locomotives on, 1889, 144-147; 1888, 149.
Engine. See LOCOMOTIVE.
Equalizers. See SPRINGS AND EQUALIZERS.
Exhaust pipes, nozzles and steam passages, 1877, 152-192; 1879, 110-161; 1890, 131-141; 1891, 30-47; 1894, 108-133; 1896, 58-148; 1897, 91-117; T 1899, 62-66.
Firemen. See ENGINEERS AND FIREMEN.

F.

Feed-water. See under BOILERS.
Flues for locomotives. See under BOILERS.
Frames, locomotive, and bracings, 1877 19-30.
  Wedges:
    Stationary, T 1895, 106-111.
    Driving-wheel, 1896, 304-308.
  Cylinder fastening, 1898, 160-187.
Fuel (see also COMBUSTION), 1874, 166-168.
  Comparative value of anthracite, bituminous and wood, 1873, 34-45.
  Economy of, T 1877, 225; paper, 1884, 156-161; use of, paper, 1872, 133-135.
  Coal delivery to tenders, 1887, 104-125.
  Kindlers, oil, 1894, 102-108; 1895, 21-40.
  Run-of-mine coal, T 1887, 11.

G.

Grate area. SEE BOILER PROPORTIONS under BOILERS.
Grates and ash-pans (see also BOILERS, PROPORTIONS):
  Smoke-stacks, grate-bars and ash-pans, 1869, 34-36; 1870, 124-125.
  Grates, anthracite, 1897, 130-166, report indexed, 131.
Gauges, Association standards:
  Sheet-metal gauge, 1882, 122-132; 1891, 160; 1899, 291.
  Sheet metal, tubes and wire, 1895, 144-150; 1899, 291.
  Round-iron limit gauges, 1884, 167; 1899, 292.
Gauge of track and wheels:
  Lateral motion, 1870, 101, 102.
  Standard vs. narrow, paper, 1873, 57-70.
  Standard and narrow gauge rolling stock, 1874, 296-305; 1875, 140, 141.
  Gauge of wheels standardized, 1884, 26.
Guides. See CROSSHEADS AND GUIDES.

H.

Handholds and steps, locomotive, 1896, 308-313.
Heating surface. See BOILER PROPORTIONS under BOILERS.
Hub liners, 1896, 245-257.

I.

Indicator. See under LOCOMOTIVES.
Injectors, is their use economical, 1876, 31-51.
Iron, wrought and malleable. See STEEL AND IRON.

J.

Joints, metallic flexible vs. rubber hose, for steam-heating connections, T 1899, 59-62.

L.

Labor. See CAPITAL AND LABOR.
Laboratory:
  Mechanical, 1874, 85-119, 153-161; 1875, 172-174; 1891, 65 90.
  Research laboratory of Association, 1899, 74-86.

Lagging for locomotive boilers. See under BOILERS.
Law:
  Legal requirements upon mechanical departments, paper, 1885, 54-60.
  Patents, infringement, paper, 1880, 81-89.
Link-motion. See under VALVES.
Locomotive:
  Classes, 1880, 18-26.
    Freight service, 1871, 63-66.
    Ten-wheel vs. eight-wheel, 1872, 161-171.
    Fast service, 1881, 66-86, 96, 100.
    Ten-wheel, vs. Mogul, 1891, 139-158.
  Compound, 1882, 60-66, paper, Webb three-cylinder; 1890, 41-66; T 1891, 97-119; 1892, 19-98; 1893, 88-137; T 1897, 75-91; T 1897, 195-197, manual vs. automatic control, T 1894, 92-102, 216-226; T 1895, 112-122.
  Construction, 1875, 73-79, 105-110; 1876, 10-18, 118-134; 1882, 106-121, 136-140; paper, 1883, 20-43; 1884, 78-84; 1885, 103-114.
  Operation and maintenance, 1894, 227-243.
    Preparation for duty, 1887, 125-133.
    High-steam pressure, 1898, 127-159.
  Performance:
    Uniform system of reports, engine-mile basis, 1870, 121-124.
    Computing mileage of switching, adopted, 1872, 100-112.
    Resolution on ton-mile basis, 1896, 333; 1899. 173.
    Tonnage rating, 1898, 52-86.
    Ton-mile basis for statistics, advantages, 1899, 162-181.
    Uniform locomotive performance, 1892, 124-134.
  Pooling, 1891, 133-139.
  Proportions. See BOILER PROPORTIONS.
  Tests, 1876, 134-154; paper, 1882, 133; 1893, 22-53, 165-173.
    Standard method of conducting, 1894, 166-200.
    Proposed shop tests at Purdue, 1895, 40-56, 130-143.
    Indicator rigging, paper, 1883, 241-253.
  Wiping, does it pay, T 1877, 99.
Lubrication. See OILS, LUBRICATING.

M.

Machinery and tools. See under SHOP.
Metric system, cost of introducing, paper, 1874, 169-183.
Motors. See under SHOP.

N.

Nuts. See SCREW THREADS.

O.

Oils, lubricating, 1871, 78-80; 1874, 240-244; 1875, 156-161; 1877, 40-51; 1879, 36-41.
  Lubrication, paper by R. H. Thurston, 1878, 53-62.
  Valves and cylinders, 1884, 119-127.
  Duty of cylinder oil, T 1887, 70-74.
  Oiling devices for long runs, 1894, 58-68.

P.

Packing, 1869, 31.
  Piston, T 1884, 77.
  Cylinder and stuffing-box, 1870, 21-35; 1871, 80-83.
    Stuffing-box, 1872, 98-100.
    Metallic, 1883, 232-241.
    Cylinder, 1887, 60-70.
    Piston rod and valve stem, 1887, 84-96, 102-104.

Patents. See under LAW.
Piecework. See under SHOP.
Pipe threads. See SCREW THREADS.
Pistons and piston rods (see also PACKING), 1895, 158-178.
  Broken piston rods, T 1893, 63-67.
  Reciprocating parts, 1896, 202-229.
  Piston rods, T 1897, 69-75.
  Extended piston rods, T 1899, 153-160.
Pooling engines. See under LOCOMOTIVES.

R.

Reciprocating parts (see also PISTONS, CROSSHEADS, COUNTERBALANCING, etc.), 1896, 202-229.
Resistance of trains (see also TRACTION):
  Dynamometer and diagrams, paper, 1881, 33-37.
  On straight and curved tracks, wide and narrow gauge, four and six wheel trucks, long and short wheel base, 1873, 77-82.
  On broad and narrow gauges, paper, 1873, 57-70.
Riveting and riveted joints:
  Soft steel rivets, 1871, 10.
  Steam machine, 1871, 75-77.
  Button-set, T 1880, 27-31.
  Comparative value of hand set and steam, 1881, 16-28.
  Sal-ammoniac for removing oxide, 1885, 38.
  Riveted joints, 1895, 178-228.
Rods:
  Solid-end connecting rods, 3 drawings, 1873, 71-77.
  Parallel rod for fast service, drawing, 1881, 68.
  Parallel rods, 20 drawings, 1882, 89-106.
  Parallel rods, formulæ, paper, 1884, 162-166.
  Method of fluting side rods, T 1893, 54-60.
Rubber hose for steam connections. See JOINTS.

S.

Sanding devices, 1894, 133-145.
Schools (see also APPRENTICES), Railway mechanical engineering in technical schools, T 1898, 108-114.
Scrap material, utilization of, 1895, 151-158.
Screw threads and nuts:
  Standard nuts, 1870, 104; 1873, 208; 1899, 289.
  Standard sizes of nuts and bolt-heads, 1892, 135-149; 1899, 290.
  Square bolt-heads and nuts, 1899, 238-272.
  Standard pipe threads, Briggs's, 1899, 235-238, 298.
Shop:
  Advantages of improved tools, 1898, 120-126.
  Flue-cutting and scarfing machine, and multiple drill for truck bars, 1880, 92-97.
  Lathe, self-acting slide, paper, 1872, 78-85.
  Machinery and tools, 1884, 85-89; 1881, 93.
  Milling machines vs. planers, 1886, 152-154.
  Motors, steam, air, electric, 1897, 260-273.
  Piecework, 1897, 241-259.
  Special tools, 1894, 146-166.
Signals:
  Train, 1875, 110-114.
  Color-blindness, address, 1883, 186-217.
Smoke-boxes, etc.; spark-arresters:
  Spark arresters, valuable history, profusely illustrated, 1883, 89-179.

- Smoke-boxes, etc.; spark-arresters (*continued*):
  - Smoke-box:
    - Extended, 1883, 180-185; T 1887, 12-31; 1888, 35-78.
    - Air openings in, T 1888, 158-161.
    - Self-cleaning, T 1898, 103-108.
  - Smoke-stacks and spark-arresters, T 1882, 143; 1885, 147-159.
    - Smoke-stacks, grate bars and ash-pans, 1869, 34-36; 1870, 124, 125.
    - Proportion of cylinder and stack diameters, T 1889, 152-158.
- Smoke prevention. See COMBUSTION.
- Snow-plows, 1873, 126-134, 8 drawings.
- Speed indicators, 1871, 66-70.
- Springs and equalizers, 1888, 99-109.
- Steam:
  - Quality, calorimeter, paper, 1881, 100-110.
  - Importance of high pressure, T 1887, 74-80.
  - Efficiency of high pressure, 1898, 127-159.
  - Gauges and testing, 1874, 64-85.
  - Heating connections, metallic joints vs. rubber hose, T 1899, 59-62.
  - Steam-pipe joints, 1896, 258-265.
  - Change of temperature in cylinder, paper, 1880, 100.
- Steam chest. See CYLINDERS.
- Steel and iron (see also BOILER STEEL):
  - Cold-rolled shafting, 1870, 117-119.
  - Case-hardened iron vs. steel, 1871, 74.
  - Steel castings for locomotives, 1885, 128-135.
  - Malleable castings, 1893, 173-175.
  - Steel in locomotive construction, T 1898, 188-194.
  - Nickel steel, 1899, 220-235.
  - Tests, 1892, 100-124; 1893, 68-87, 138-144.
- Steps, locomotive and tender:
  - Steps and handholds, 1896, 308-313.
  - Steps on pilot, 1888, 162.

T.

- Tender, locomotive:
  - Frames, wood and iron, T 1878, 216-218; 1893, 201-205, 5 drawings.
  - Tanks, prevention of corrosion, 1890, 154-158.
  - Attachments between engine and tender, foot-steps and hand-rails, 1893, 175-184.
- Tires (see also WHEELS):
  - Blind tires and swing truck, T 1888, 29-32; T 1895, 56-67.
  - Flanged tires on all drivers, 1899, 202-219.
  - Locomotive, 1874, 207-222; 1875, 115-125.
  - Standard diameters, 1870, 40-43; 1887, 133-140; 1899, 293.
  - Standard sections, 1886, 80-90; 1887, 136; 1893, 144-148; 1899, 294.
  - Shrinkage, 1899, 293; 1894, 201, large tires.
  - Steel tires, wheels and axles, 1869, 41-55; 1870, 58-85; 1871, 46-60; 1873, 176-191, and chilled tires.
  - Steel-tired vs. cast-iron wheels, 1899, 124-147.
  - Taper fit, T 1884, 22.
  - Thick vs. thin, 1888, 109-121; 1889, 28-36; 1887, 139.
  - Treatment and retaining rings, 1894, 201-216.
  - Wear:
    - Thickness at removal, T 1884, 18-22.
    - Engineer's control over, 1887, 140-147.
    - Driving tires, 1895, 228-271.
    - Permissible, 1894, 201.
- Tools for shops. See under SHOPS.
- Traction, paper, 1869, 70-73.
  - Increasers, 1887, 50-58; 1888, 143-148; T 1885, 28.

Trucks:
- Chains, efficiency of safety or check, 1873, 83-96.
- Engine and tender, 20 drawings, 1877, 193-220.
- Pony, safeness for fast service, T 1890, 32-38, 89-95.
- Swing hangers, 1896, 313-325; 1897, 123-129.
- Swing and blind tires, T 1888, 29; T 1895, 56-67.
- Tender, 1888, 132-142.

V.

Valves:
- Best location of check, 1883, 218-221.
- Relief and by-pass, T 1899, 273-276.
- Check, T 1886, 32; T 1882, 31.
- Safety, 1869, 32-34; 1870, 38; 1872, 172, 173; 1874, 53-85.
- Noise prevention, 1880, 75-79.

Valves and valve gear:
- Balanced valves, 1870, 85, 86; 1873, 99-117; 1884, 112-119; 1886, 117-134.
- Lap and lead, 1870, 56-58; 1872, 96-98.
- Lead for passenger, freight and yard engines, T 1897, 199, 200.
- Metal, best for cylinders, valves and seats, 1897, 203-218.
- Piston valves for simple locomotives, T 1897, 190-192.
- Seats, securing false, T 1889, 158.
- Testing graphically motion of valves, paper, 1873, 197-200.
- Slide valves, 1896, 161-200.
- Valves and valve gear, paper, 1873, 118-126; 1874, 184-207; 1877, 30-38; 1884, 107-119.
- Valves, best arrangement for 4½-inch cut-off, 1878, 114-199.
- Joy valve gear, paper by inventor, 1882, 55-67, 81-88.
- Link, compared with other motions, 1890, 69-88.
- Some modern valve gears, paper, 1885, 92-103.
- Improvements, 1885, 77-91.
- Steam reverse gear 1882, 109, 110.

W.

Water. See BOILERS, FEED-WATER BOILERS, INCRUSTATION AND WATER PURIFICATION.

Wedges. See FRAME, LOCOMOTIVE.

Weight:
- Limit per wheel on locomotive, T 1882, 25-31.
- Dead, reduction of, 1870, 107-114; 1871, 39-45.

Wheels (see also TIRES):
- Steel tires, wheels and axles, 1869, 41-55; 1870, 58-85; 1871, 46-60; 1873, 176-191.
- Cast-iron, standard tests, form of contract and service guarantee, approved, 1888 151-158.
- Cast-iron vs. steel-tired, for locomotives and cars, T 1877, 226; 1899, 124-147.
- Diameters of centers, standard, 1886, 80-90; 1893, 144-148; 1899, 293.
- Flanges, minimum thickness (1 inch) of engine truck, 1896, 325-331.
- Forcing wheels, pressures, 1873, 140-142, 146.
- Gauge. See GAUGE OF TRACK AND WHEELS.
- Hub liners, 1896, 245-257.
- Best form and material for locomotive wheels and axles, 1878, 20-50; 1879, 45-52.
- Treads, coning, 1884, 128 155.
- Tender and locomotive truck, 1875, 115-125; 1884, 90-95.

Wrecks, machinery for removing, 1873, 172-175.

CLASSIFIED INDEX

OF THE

SUBJECTS DISCUSSED AND REPORTS SUBMITTED,

In the order in which they appear in the Annual Reports of the Proceedings.

SCHEME OF NOMENCLATURE.

Recommendations formally adopted, or *motions* or *resolutions* approved by vote of the Association are numbered as follows	1
Valuable Reports, discussed, but not formally adopted, though accepted as carrying the sense of the meeting at which they came up, are numbered as follows	2
Reports on which the discussion was so divided that no definite conclusion as to the sense of meetings at which they were discussed could be formed, are numbered as follows	3
Reports on which the discussion was adverse are numbered as follows	4
Reports which appear to have little or no value are numbered as follows	5
Reports which, though making no definite recommendations are valuable for the information they contain, are numbered as follows	6

As some of the Reports and Recommendations, though once of value, are of no practical importance today on account of the lapse of time, there is a further subclassification as follows:

Reports or *Recommendations* of value today, even if only in part, are lettered	a
Reports or *Recommendations* of doubtful value today are lettered	b
Reports or *Recommendations* of no value today, either because they are not applicable to present conditions, or simply state facts or truisms, are lettered	c
Reports or *Recommendations* which have been superseded or annulled by subsequent action are lettered	x

Important Reports or *Recommendations* having special interest even at the present time are numbered and lettered in *heavy-faced type*.

LIST OF SUBJECTS, 1868-1899.

1868 None.

1869

PAGE		
21	Report on Locomotive Boilers	2 c
31	" Packing	2 c
32	" Safety Valves	2 c
34	" Smoke Stacks, Grate Bars and Ash Pans	2 c
41	" Steel Tires, Wheels and Axles	2 c
55	" Boiler Explosions	6 a
	Recommends hollow stay bolts.	
67	Report on Boiler Incrustations	6 a
70	Paper on Traction	6 a
1870		
12	Report on Boilers and Boiler Material	2 c
21	" Cylinder and Stuffing-box Packing	3 b
36	Paper on Boiler Incrustation	6 a
38	Report on Safety Valves	5
40	" Uniform Sizes of Tires	3 c
44	" Construction of Furnaces	6 b
	Jauriet fire box (C. B. & Q.) with water table more economical than plain fire box, from experiments. (In later years much trouble about repairs.)	
49	Paper on Combustion in Locomotives	6 a
56	Report on Lap and Lead of Slide Valves. (Gives figures in use.)	6 b
58	" Steel Tires, Wheels and Axles	6 c
85	" Boiler Explosions	6 a
101	" Lateral Motion (between flange and rail)	6 c
104	" **Standard Nuts.** [See also **1899, page 289.**]	2 a
	Recommends the adoption of U. S. Standard Nuts, which the convention unintentionally forgot to do, formal action being taken in 1873. [See page 208 of that year.]	
104	Report on Flues (copper vs. iron, mostly)	6 c
107	" Reduction of Dead Weight in Rolling Stock	6 a
117	" Cold Rolled Shafting	6 a
119	" Braking on Rail	6 c
121	" Uniform System of Locomotive Reports (*Engine-mile* basis).	
	Form for performance sheets as printed on page 122 adopted	X 1 c
	Recommends 10 miles per hour for switching engines and 5% for freight engines switching at stations	X 2 c
124	Report on Smoke Stacks, etc	2 c
1871		
10	Report on Boilers, Boiler Material and Soft Steel Rivets	2 c
20-32	" Boiler Incrustations	6 a
32-37	" Boiler Explosions	6 a
39-45	" Dead Weight	6 a
46-60	" Steel Tires, etc	6 c
60-63	" Construction of Furnaces	6 a
63-66	" Locomotives for Freight Service	2 c
66-70	" Speed Indicators	6 a
71-72	Report on Application of Compressed Brake.	
	Recommends Westinghouse air brake	2 c
74	**Report on Case-hardened Iron vs. Steel**	2 a
	Case-hardened iron preferable to steel for working parts of locomotives, including guide bars and crank pins.	
75-77	**Report on Steam Machine Riveting.**	
	Superiority over hand riveting	2 a
78-80	Report on Lubricating Oils	2 c
80	" Cylinder and Stuffing-box Packing	2 c
86	" Proportion of Water Space and Steam Space to Heating Surface	6 b

1872

PAGE		
13-62	**Report on Boilers and Boiler Material**	2 a
	Drill longitudinal seam holes. Do not use drift pin, but ream. Use hollow stay bolts.	
62-78	Report on Relative Merit of Straight and Wagon Top Boilers	3 a
78-85	Paper on Self-acting Slide Lathe	6 a
90-95	Report on Purifying Water for Boilers	6 a
96-98	" Lap and Lead of Slide Valves	6 c
98-100	" Packing for Stuffing Boxes	6 c
100-112	" **Computing Mileage of Engines Doing Switching Service.**	1 a
	[See Note on page 124 of year 1892.]	
	Report adopted:	
	For switching engines allow six miles per hour of actual service.	
	For local freight engines allow 6 per cent for switching.	
	New engines to replace old ones should be charged to "repairs," except any excess in cost.	
113-133	Report on Application of Compression Brakes	2 c
	All in favor of brake controlled by engineer.	
	Westinghouse brake much favored.	
137-160	Report on Boiler Incrustation	6 a
161-171	" Comparative Cost and Performance of Ten-wheel and Eight-wheel Engines	6 b
172-173	" Safety Valves	6 c
178-188	" Uniform System of Examination for Promotion of Firemen and Advisability of Establishing Different Grades of Engineers	6 a
188-193	" Best Method of Securing Driving and Truck Brasses	6 c
176 193-199	" Boiler Explosions	6 a

1873

11-28	" Operation and Management of Locomotive Boilers, including Purification of Water	2 c
	Brief review of former reports. Analysis of distilled sea water showed a trace of hydrochloric acid. Recommend use of surface and rain water and thorough and frequent washing as the best and most reliable cure.	
34-45	Report on Comparative Value of Anthracite and Bituminous Coal and Wood for Generating Steam in Locomotives	6 c
48-54	Report on Construction, Operation and Cost of Maintaining Continuous Train Brakes	6 c
54-56	Report on Application of Compression Brakes	6 c
57-63 63-70	Paper on Cost of Operating Roads of Standard and Narrow Gauges	6 c
	Very good paper, stating clearly advantages and disadvantages.	
71-77	Report on Construction and Operation of Solid End Connecting Rods for Locomotives. Three drawings	6 c
77-82	Report on Resistance of Trains on Straight and Curved Tracks, Wide and Narrow Gauge, and with Four or Six Wheeled Trucks, and with Long and Short Wheel Base	6 a
83-96	Report on Efficiency of Check or Safety Chains on Engine, Tender and Car Trucks in Lessening Danger Resulting from Running Off the Track	1 b
	Motion carried "that it is the sense of this Association that all trucks under all engines, tenders and cars should be provided with safety chains."	
99-117	Report on Anti-Friction Valves	2 c
	Use of balanced valves recommended. Seven drawings.	
118-126	Paper on Valves and Valve Motions	6 c
126-134	Report on Machinery for Removing Snow from the Track	6 a
	Short treatise. Eight drawings.	
135-172	Report on Best Form and Proportions of Axles for Cars and Locomotives; also Compound Axles and Loose Wheels. Forcing Wheels: on cars, pressure varies from 14 tons to 45 tons; on locomotives, 28 to 100 tons. (Sizes not stated.)	6 c
	Page 143.—Resolution carried "that in the opinion of this Association no practical advantage will result from the use of loose wheels or compound axles in ordinary railway service."	1 c
172-175	Report on Machinery for Removing Wrecks	2 c
	Recommend a good assortment of strong lines, good blocks, jacks and hand tools, kept in a tool car, conveniently arranged for storing the tools and ready for immediate use.	
176 191	Report on Steel Tires, Wheels and Axles, and Chilled Tires	6 c
197 200	Paper on a Proposed Method of Testing Graphically the Actual Motion of Slide Valves. Drawings	6 a
208	Report on Standard Sizes of Nuts	X 1 c
	"The sizes of nuts as adopted by the Manufacturers' Association, December 11, 1872," adopted.	
207-222	Report on Locomotive Tires	6 c
223-239	" Standard Axles	6 a

1873

PAGE		
240-244	Report on Best Lubricants for Locomotive Use Lard oil recommended.	2 c
244-278	Report on Continuous Train Brakes	2 c
282-295	Paper on railroad engineering by an associate member	6 a
296-305	Report on Narrow and Broad Gauge Rolling Stock	6 c

1874

20-53 119-153 162-165	Report on Operation and Management of Boilers, including Purification of Water	6 a
53-85	Report on Best Form of Safety Valve and Best Way of Testing Pressure Gauges	6 c
85-119 153-161	Report on Mechanical Laboratory	6 b
166-168	" Fuel for Locomotives	6 c
168-183	Paper on Cost of Introducing Metric System	6 c
184-207	Report on Valves and Valve Gear	6 c

1875

15-48 79-103	Report on Locomotive Boilers	6 a
48-72	" Purification of Feed Water Recommends purification of water before it enters the boiler: first, by using rain and surface water, properly filtered; second, by use of chemicals in tanks, two being required [page 51, 55].	X 2 a
73-79 105-110	Report on Locomotive Construction	6 b
110-114	" Train Signals	6 c
115-125	" Locomotive Tires, Truck and Tender Wheels	6 c
125-140	" Continuous Train Brakes	6 c
140-141	" Narrow and Broad Gauge Rolling Stock	6 c
142-155	" Machinery for Supplying Water to Tanks	6 c
156-161	" Lubricants for Locomotives	6 c
161-172 188-199	" Standard Axles	3 c
172-174	" Mechanical Laboratory	6 c
184-188	" Axle Tests. Results of experiments	6 c

1876

10-18 118-134	Report on Construction of Locomotive Engines	6 c
20-31	" Best and Most Economical Metal for Locomotive and Tender Bearings	6 b
31-51	" "Is It Economical to Use Injectors on Locomotives?" Injectors a little better than pumps.	2 c
52-118	" Best Materials, Form and Proportions of Locomotive Boilers and Fireboxes	6 a
134-154	" Locomotive Tests	6 b

1877

19-30	**Report on Locomotive Frames and Bracings** *Recommends wooden bumpers instead of iron; two wedges in one pedestal not recommended. Cylinder castings should be held mostly by lugs on frames. Frames should be strong enough to require no assistance from boiler, etc.*	2 a
30-38	Report on Slide Valve and Valve Gearing	2 b
40-51	" Lubricants. Recommends for lubrication of the machinery of locomotives and journals of locomotives and cars, a "good quality of natural earth oil." Results of test	2 c
51-98 113-134	Report on Locomotive Boilers and Fire Boxes Recommends steel for shell and fire box; wagon top better than straight; hollow stay-bolts above grate to let in air. Brick arch recommended; best for fast trains worked to full capacity, preventing drawing of coal through tubes and prolonging passage of gases.	X 2 a
135-152	Report on Best Point in Boiler to Introduce Feed Water, and Incrustation. Introduce feed-water near front flue sheet on the side. Compounds no good. Construct artificial surface reservoirs or purify in tanks.	X 2 a
152-192	Report on Locomotive Tests Tests on railroad in South America with adjustable petticoat pipe, exhaust pipe and baffle plates in fire box.	X 6 a
193-220	Report on Engine and Tender Trucks Drawings of about 20 trucks.	6 a

1878

20-50	Report on Best Form and Material for Locomotive Wheels and Axles; also Best Method of Counterbalancing	3 c
53-62	Paper on Lubrication by R. H. Thurston	6 a

1878

PAGE

63-65 Subject for discussion: "**Best and Most Economical Method of Caring for Locomotive Boilers When in Service.**"........................ **3 a**

65-110 **Report on Locomotive Boilers**.. **6 a**
Drawing shown of an improved (now poor) form of riveting for longitudinal seams with a welt over lap. Steel for fire boxes favored unanimously. Corrugated fire box side sheets recommended to prevent cracking.

114-199 **Report on Locomotive Tests**.. **6 a**
Exhaustive report by John E. Martin, of Chile, on experiments with 8-wheel passenger locomotive, at 4½-inch cut-off, ascertaining best arrangement of valves, etc. Tests with dead plates in fire box. Indicator cards.

200-213 **Paper on Capital and Labor. To the point**.............................. **6 a**

213-216 **Discussion on "What is the best plan of testing boiler, hydraulic or otherwise." General opinion: hydraulic, but with various details** ....X **2 a**

216-218 **Discussion.—What is the best material for tender frames?**.............. **6 a**
Iron mostly favored.

1879

14-35 } 52-58 } **Report on Standard Car and Tender Axles.** [1891. Page 160.]......... **1 a**
M. C. B. Standard. 3¾" by 7" journal, adopted. (*Drawing, page 22.*)

36-41 Report on Lubricants. Natural oils recommended for general use....... **2 c**

45-52 " Best Form and Material for Locomotive Wheels and Axles... **6 c**

59-107 Report on Boilers.. **2 b**
Steel recommended by nearly all. Lap seam with welt over it most generally used and considered best. Annealing of flange sheets recommended (page 68). Straight top more preferred. Corrugated side sheets recommended, also large fire box.

110-161 Report on Performance of Locomotives...............................X **2 a**
Exhaustive experiments in South America on Exhaust Nozzles, showing that the single nozzle, when it can be made of a large size, is superior to the double form, being more economical and throwing less fire. The "compound nozzle" or combination of the two forms, not only unites the good qualities of both in one, but gives a lower vacuum and higher evaporation than the single and a more perfect exhaust than the double form. [Page 159.]

1880

14-17 } 50-68 } Report on Boilers. High claims for radial stay boiler; scale easy to get at and slope prevents deposit.. **6 a**

18-26 } 68 } Report on Comparative Performance of Locomotives.................... **3 b**
Heavy freight service not to exceed 12 miles per hr.—Consolidation best
General " " " " " 15 " " " Mogul best.
Fast " " " " " 20 " " " 8-wheel "

26-31 Topic: Is button-set riveting reliable?.................................. **3 c**

31-32 " What is best method of annealing sheets? Wood fire only should be used; no coal.. **6 b**

37-49 } 69-71 } Report on Best Means of Preventing Smoke ....X **2 a**
"Large boilers and fire boxes and *careful firing* are the best means of preventing smoke from locomotives with due economy in fuel." [Page 49.]

73-74 **Topical Discussion: Are sling stays from the crown bars to the outside shell of the boiler necessary to hold the crown and make the boiler safe?** .... **2 a**
All who spoke, in their favor. Belpaire boiler introduced to the convention.

75-79 Report on Best Means of Preventing Noise from Safety Valves.......... **6 a**
The noise can be prevented by passing the steam to the tender and then condensing it, and by the use of a muffler with many small orifices.

81-89 Paper on Infringement of Patents.. **6 a**

92-97 Report on Tools and Machinery. Description, with drawings, of a flue cutting and scarfing machine. Multiple drill for truck bars, with drawing.. **6 a**

1881

16-28 **Report on Boiler Construction and Improvement** .... **2 a**
Set riveting recommended. Superior to hand riveting in cost and quality of work. For work on a large scale, steam riveting best Drawings of sections of plate through rivets by the three above methods. With a number of experiments on a model boiler, rivets put in by hand always yielded before the button set ones.

28-33 } 44-50 } Report on Boilers, by J. Johann. Radial stay boiler recommended....... **4 a**

33-37 Paper on Train Resistance and Dynamometer, with diagrams............ **6 a**

52-66 **Report on Best Means of Producing Better Combustion in the Use of Bituminous Coal as Fuel for Locomotives.**
Table showing evaporation with high and low exhaust nozzles (*page 63*) *in favor of high exhaust nozzle No general rule on account of variety in coals. Two things are important, first, a large fire box and plenty of heating surface; and second, care and intelligence on the part of the fireman*..... **2 a**

1881

PAGE

66-86 Report on the "Best Form of Construction of Locomotives for Fast Passenger Trains" .... 2 c

8-wheel engine best. Engine with two drivers not enough adhesion. Drawing of parallel rod for *fast service* with keys and *rectangular* section.

100-110 Paper on The Quality of Steam, dwelling on importance of knowing it when investigating boiler performance. Calorimeter described...... 6 a

110-115 **Report on Standard Journal Bearing, Box and Pedestal.** Made standard, for use on cars and locomotive tenders. Journal, 3¾" by 7". Pedestal still standard of M. C. B. Association. Details of Journal Box and Bearing **obsolete in M. C. B. Association, '99.** Not revised by M. M. Association. (See 1891, page 160)............... 1 a

116-120 **Paper on Clearance and Compression in Steam Cylinders**............. 2 a

Small clearance best. Sufficient compression necessary.

120-129 Paper of M. N. Forney on "Attachments to Locomotive Boilers" which are liable to break off and scald people in case of accident, horrible examples of which are given. Feed water check valve especially important. Should be inside, so attached that the whole can be removed for grinding. [Example, Modern Locomotives, page 297, P. R. R.] For other valves it is suggested, "let the valve be larger than the orifice and on the inside of the boiler, and let the turning of the screw push it into the boiler ....X 2 a

1882

12-24 }
33-55 } Report on Improvements in Boiler Construction.................... 6 b

All laps exposed to the fire should be short to prevent burning. Drawing of Belpaire boiler.

Experiment with a Baldwin Consol. having Wooten fire box and using Illinois soft coal. Engine "performed remarkably well." [page 41.]

25-31 Topic: Limit of weight to be allowed per wheel for locomotives......... 6 c

55-67 }
81-88 } Paper on Joy Valve Gear and Webb's Compound Locomotive, by David Joy. Diagram comparing with link motion.......................... 6 c

68-71 Topic: What is best method of welding flues?......................... 6 c

Machines for this work spoken of highly.

74-80 Paper on Safety Attachments to Locomotive Boilers ....X 2 a

Drawings of check valve and "steam gauge stand" which prevent the escape of steam if knocked off in case of accident. (1893, 149.)

89-106 **Report on Side Rods, designed to prevent their breaking**............ 2 a

Drawings of about 20 rods. A rod (Fig. 4) of I section, and bushed brasses favored.

106-121 }
136-140 } Report on New Plans of Construction and Improvement of Locomotive Engines .... 6 b

Drawing of Penn. R. R. method of supporting brick arch on water tubes.

Drawing of Steam reverse gears, and descriptions, of two kinds.

Details of high-speed 8-wheel locomotive.

General plan of 8-wheel locomotive, with Wooten fire box (Philadelphia & Reading.)

General plan of Strong locomotive, with corrugated fire box and two main rods on a side, doing away with parallel rod.

122-132 **Report on Standard Wire Gauges. [1899, page 291.]**................ 1 a

Brown and Sharpe micrometer gauge [*i. e., decimals of an inch*] *adopted as a standard for measurement of sheet metal.* [*Reaffirmed 1891, page 160.*]

1883

20-28 Paper on Improvements in Locomotives with Reference to Efficiency and Style of Finish.. 4 c

Recommendations.—Joy valve gear; perforated dry pipe with no dome; plate frame to get wider fire box, etc. Simplicity; no moldings on sand box and dome cover.

45-64 Report on Most Practicable and Best System of Paying Premiums to Locomotive Engineers and Firemen to Induce Economy in Working Locomotives .... 2 b

13 blanks given to be used in system recommended. One-half of what the engineer and fireman save in fuel above a given amount goes to them. Worked on basis of a loaded box car [page 48]; 3 empty, equal 2 loaded. (No discussion.)

64-89 Report on Improvements in Locomotive Boilers.......................... 6 a

Report simply consists of 16 plates showing boilers of all descriptions, including the oval barrel, with description of each.

89-179 Report on Spark Arresters. [Valuable history] .... 6 a

It gives an *exhaustive* review of the various lines along which inventors have worked, including 115 exhibits of drawings of patents issued, 55 pages of drawings, with brief description of each.

180-185 Report: Is the Extension of the Smoke Box Beneficial? If so, to What Extent?..X 2 a

They "find the extended smoke box beneficial to this extent, namely, economy in fuel, cones, netting, smokestacks, etc.; also more free and regular steaming qualities, insuring against fires and guaranteeing

1883
PAGE

cleanliness to both train and engine.' Drawings shown of smoke box, 6½ feet long from the flue sheet. Also table showing economy made by putting on extension.

186-217 Paper on Defective Vision Among Railroad Employes, by Dr. Jeffries... **6 a**
Tells importance of the subject and pleas for proper testing of color-blindness, which is generally carried on in such a crude fashion. Holmgren's worsted test is best.

218-221 Report on Best Position for Check Valves.................................. **6 b**
Somewhere in front of boiler best.

221-232 **Paper on Standard Reamers for Locomotive Use, by Coleman Sellers** **2 a**
Description of system of gauges to be used with tapered reamers, and advantages of tapered bolts. (See also 1890, page 28.)

232-241 Report on, Is the Use of Metallic Packing Desirable?...................... **3 c**
Majority favor it. No recommendation.

241-253 Paper on Application of Indicator to Locomotives ....X **2 a**
Practical paper with details of rigging.

1884

18-22 Topic: "At what thickness should steel tires be removed to insure safety from accident by breakage?"..X **6 c**

22-25 Topic: "Why should we not press on our tires cold with a taper fit, instead of shrinking them on?"... **4 c**

25-27 **Motion made and carried "that the standard distance between the backs of tires for tender wheels, locomotive truck wheels and driving wheels be 4'-5⅜" standard [same as M. C. B. 1883] with limits 4'-5¼" to 4'-5½"**.. **1 a**
[*Made standard by M. C. B. Association 1885, and is their standard, 1899.*]

27-75 Report on Improvements in Locomotive Boilers.......................... **6 a**
Drawings of 12 boilers of various kinds with short descriptions. Radial stay boilers found to give excellent service [page 35]. *15 points on which there is general uniformity of opinion* [*page 41*], *8 points on which there is no general uniformity of opinion* [*page 42*]. Details of experiment with Hutchinson Smoke Consumer, consisting of 6 steam jets ($\frac{7}{64}''$) to draw air into the fire box (drawing). No gain in *economy* of fuel, the fuel saved being used in making the extra steam. Smoke and fine cinders consumed to some extent, but requires judicious firing. Double riveting for mud ring recommended by two members.

78-84 Report on Construction and Improvement in Locomotives .... **6 b**
Very little change or improvement. Wood cut of 8-coupled engine with two pony trucks; general plan of mogul engine and iron tender truck.

85-89 Report on Shop Tools and Machinery .... **2 c**
Recommend stud machine in larger shops. Recommend, in interest of uniformity, that all bolts, studs and set screws be cut or finished in dies.

90-95 Report on Best Material for Locomotive Truck and Tender Wheels...... **3 c**

95-106 Report on Best Mode and Manner of Educating Young Men for Engineers **2 b**
1. Qualifications for position of fireman given; 18 to 24 years, etc.
2. Three grades of firemen, 4 years' duration. One year in shop.
3. Three grades of engineers.

107-119 Report on Valve Motion and Balanced Slide Valve .... **2 c**
Page 107.—"While the link motion device may not be a correct one for the distribution of steam, yet when an average is struck between its simplicity, durability and efficiency, and various other suggested devices, the result is in favor of the link motion." With large valves, balancing is necessary. Richardson valve is much used. Drawings of two kinds of balanced valves.

119-127 Report on Best Method and Material for Lubricating Valves and Cylinders **2 c**
Sight-feed lubricator best with pipes running to steam chest instead of to dry pipe. Tallow objected to on account of its corrosive action.

128-155 Report on Coning of the Tread of Wheels.................................. **6 c**
Practice of members stated. No uniformity.

156-161 Paper on Fuel Economy with Locomotives, by Angus Sinclair............ **6 a**
Gives some causes for waste of fuel. Very much depends on engineers and firemen.

162-166 **Paper on the Theory of Stresses in Locomotive Coupling Rods, by F. W. Dean** .... **2 a**
Gives formulæ for practical use for rectangular and I sections.

167-168 **Pratt and Whitney limit gauges for round iron for Seller's standard threads, adopted as standard [see also page 292 for year 1899]** **1 a**

1885

18-20 Report of secretary on standards adopted to date.

33-47 }
63-76 } **Report on Boiler Construction** .... **2 a**

Consists of a résumé of the past work on this subject, noting the points along which progress has been made, page 38: "To remove scale and save unnecessary caulking, a clean metallic joint can be secured by passing over the two surfaces, waste wet with a weak solution of sal-ammoniac and hot water" .... **2 a**

1885
PAGE

Page 45.—" Pitting can be stopped and the plate brought into a healthy condition, by scraping the affected parts and cleansing the surface with a strong solution of soda or petroleum to remove any grease or acidity, and then coating with a thin wash of Fortland cement. Red lead also good.

Page 67.—Motion made and carried "that it is the sense of this Convention that steel is the proper material for fire boxes"...... 1 c

Punching of plates now almost universal practice, against previous recommendations. Steel rivet heads fly off too much.

54-60 Paper on Legal Requirements upon the Mechanical Departments of Railways.. 6 a

77-91 **Report on Improvements in Locomotive Valve Gear**.................. 2 a

Constant lead with Joy gear considered detriment; also parts wear too much, but fire box can be made longer because eccentrics not in the way. Drawings of Clark's, Stevens', Walschaart, and Allan, link motion gears. On the whole, ordinary link motion best.

92-103 Paper on Some Modern Valve Gear: Brown and Strong, with gridiron valve. Drawings.. 6 b

103-114 Report on New Plans for Construction and Improvement of the Locomotive.. 6 b

Drawing of Forney's Patent Locomotive.
" and description of Baldwin decapod.
" of fire box with crown sheet made in longitudinal sections, which was satisfactory for 7 years on Chicago & Iowa R. R. Four drawings showing method of lagging sides of fire box and boiler heads; asbestos, ¼"; hair felt, 1"; planished iron.

Drawings of Dean's dustproof, box form guides, with cross head.

115-127 Report on Best Metal for Locomotive Bearings........................... 6 b

Drawings of various bearings and boxes. Solid bushes for side rods giving good service.

128-135 Report on Steel Castings for Locomotive Work .... 6 a

Steel castings much more reliable than cast iron, but not so reliable as wrought iron. Very poor bearing metal. Good substitute for expensive forgings.

138-144 **Report on Hydraulic Test for Locomotives**.............................. 2 a

P. R. R. rules given. Recommendations of committee on page 140, for new boilers: Introduce hot water, and when warmed through, apply pressure and examine for change in shape. Later, examine stays and braces. For subsequent tests use 25 pounds above working pressure (test to 180 pounds new [working pressure not given]).

147-159 Report on Smoke Stacks and Spark Arresters............................X 2 c

An extension front makes very satisfactory spark arrester. Use brick arch only where you have comparatively pure water and coal.

1886

26 **Resolution passed, " That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry.** 1 a

33 M. N. Forney makes a plea for having the attachments to boilers made in such a way so as not to scald people to death in case they are broken off in accident, as often happens. [1881, page 120; 1882, page 74; 1893, page 149.]

41-79 Report on Improvement of Locomotive Boiler Construction.............. 6 a

20 drawings. Letter on a comparison of first cost and maintenance betweeen boilers using hard and soft coal [45-47.]

Paper by J. Snowden Bell, giving a history, with drawings, of some early boilers, dwelling largely on the construction of the grates, and ending with an extended account of Wooten boiler, and comparing it with usual type.

Paper, with drawings, on experiments with curved seam; 32 per cent stronger than straight lap.

80-90 **Report on Standard Diameters of Driving Wheel Centers and Standard Section of Tires.** Standard centers adopted as follows: **38", 44", 50", 56", 62", and 66". See also page 293, 1899**..................... 1 a

95-115 Report on Driving Wheel Brakes.. 6 c

Majority favor them, but many do not. Report gives some history.

117-134 Report on Balanced Slide Valves... 6 c

A compendium of experiences and opinions, with drawings. A piston valve shown as used in ordinary steam chest.

136-152 Report on Best Plan of Removing, Cleaning and Resetting Flues........ 2 b

The sense of the convention (by vote, 46-28) was " that in practice it is unnecessary to bead flues in front end "................................ 1 a

Conclusions of committee (8 items), pages 143-144; cutter bar, tumbling barrel; copper ferrule, roll, bead back end, weld or braze.

152-154 Report on Shop Tools and Machinery....................................... 2 b

Milling machines *vs.* Planers. Milling machine best for small work.

155-158 Report on Hammer Blow or Magnitude or Variation of Pressure Under Driving Wheels. Recommend construction of dynamometer. No action.. 6 c

1887

PAGE

12-31 Discussion on Extension Smoke Boxes.................................X 6
Favored by majority. Many find them of more value in connection with brick arch.

36-50 **Report on Proportion of Locomotive Cylinders**........................ 2 a
Recommends formula [page 43]: $\frac{d^2 \times S \times P \times .85 \times C}{D} = W$, in which D = diameter of tires half worn; d = diameter of cylinder; S = stroke; P = boiler pressure; W = weight on driving wheels; C = coefficient for adhesion = $\frac{1}{4}$ for passenger engines, $\frac{1}{4.25}$ for freight engines, $\frac{1}{4.5}$ for switch engines. Table given applying formula to 42 locomotives for comparison with actual construction.

50-58 Report on Traction Increasers.. 6 c
Majority against them. Report simply gives opinions of members.

60-70 Report on Cylinder Packing.. 6 b
General practice, cast-iron snap rings.

70-74 Topic: Duty of Cylinder Oil. Do not be too economical.................. 6 b

74-80 Topic: Importance of Higher Steam Pressure............................. 6 b

84-96 }
102-104 } Report on Piston Rod and Valve Stem Packing............................ 2 c
Metallic packing very satisfactory. Nine kinds shown.

104-125 **Report on Coal Delivery to Tenders**.................................... 2 a
"The cheapest and most rapid delivery is by using high central trestle, from which the coal is allowed to gravitate into dimensioned chutes, and from the chutes gravitate into tender." Other methods for different conditions. (9 drawings.)

125-133 Report on Locomotive Preparation.. 2 b
Conclusion: With boilers, accessible inside, best system for washing out is by means of high-service storage tank in connection with a stationary boiler and proper piping for blower and blow-cock connections, and the steam boiler washer (good ones on the market); the live engine to contribute its steam to heating the storage tank, and in return, when washed, to receive its full of hot water from that source.

133-140 **Report on Standard Diameter of Locomotive Driving Wheel Centers**. 1 a
Page 135; standard inside diameter of tires adopted: 37.960", 43.953", 49.947", 55.940", 61.934", 65.930". [See also **page 293, 1899,** Pratt & Whitney gauges.] Pages 137, 134; M. C. B. tire section made standard for driving wheels. [See also **page 294, 1899,** shaded portion.]

140-147 **Report on What Control has Engineer over Wear of Driving Wheel Tires**... 2 a
He has a great deal to do with it, by a judicious manipulation of the sand, and by care in starting. By having regular engineers on engines, there is a saving of 10 to 20 per cent in wear of tires.

1888

19-27 **Report on Relative Proportions of Cylinders and Driving Wheels to Boilers**.. 2 a
Recommendation: For average practice, 2 square feet of heating surface for each horse-power developed (maximum). Following formulæ on assumption of piston speed of 800 feet per minute, in connection with 40 per cent boiler pressure, 24-inch stroke:

A. Piston area of one cylinder in square inches × 5.8 = total heating surface, square feet.
B. Total heating surface ÷ 70 = grate area.
D. " " " ÷ 400 = flue area.

28-29 Topic: Effect of Height of Boiler on Lateral wear of Boxes............. 6 a
Less lateral wear with high boiler if sufficient lateral motion is given at first. If too little lateral motion, cutting occurs, and moguls liable to leave track at frogs.

29-32 Topic: Swing Trucks and Position of Blind Tires......................... 6 a
On 10-wheel engines, front tires bald with rigid truck preferred.

32-33 Topic: Method of Securing Crown Sheet................................... 6 a
Radial stays preferred to crown bars.

35-78 **Report on Extension Fronts and Brick and Other Fire Box Arches**.... 2 a
Conclusions of committee:
Dimensions to be determined with kind of coal used. Base efficiency on the actual combustible matter in the coal. Use *great care* in reaching conclusions. Extension fronts are a decided improvement with average bituminous coal, as "spark arresters, cleanliness to trains, and economy of maintenance, when properly constructed and within certain proportions." Brick arches favored. Should not come less than 1" from side sheets and 2" from tube sheet. (Use of water-tubes implied.) Hollow stay bolts not as good as having a moderate and uniform depth of fire. Importance of careful firing dwelled upon: little coal at one time. Ninety pounds of coal per square foot of grate area per hour should be a maximum. Smoke, once formed, can not be consumed. What is needed is therefore a smoke-preventing furnace. On motion, convention unanimous in favor of, *"that a brick arch applied to the fire box of the locomotive is a desirable addition for all service, and a positive advantage."*... 1 a

1888

PAGE

78-97 Report on Cross Heads and Guides ... **2 b**

The committee gives *eight requisites* of a cross head guide, page 80, but leaves out the important consideration of a balanced cross head for high-piston speeds. It investigates the modern four-bar, Laird, single-bar, two-bar (steamboat), and Dean patent, dustproof, box form.

It recommends for 8-wheel, American type, and 10-wheel locomotives the Dean type *(unbalanced)*. For moguls, consols and decapods, Laird type. For switching, Laird. Cast iron for guides and steel for cross heads. Cast-iron gibs for open-hearth steel castings.

97-99 Discussion on, To Promote Adoption of Standards ... **6 a**

It occurred to the Secretary that it would be a good idea to write to members, asking what they are doing, and what they propose to do in regard to adopting standards. Two members say that standards can not be adopted at once. (Nothing done.)

99-109 Report on Springs and Equalizers ... **2 b**

Drawings of practices of different roads.

Recommendations: 3½" x ⅜" crucible cast steel for driver and engine truck springs; 36" from center to center for the springs; 12 plates for driving spring, with 14,000 on each driver; 16 plates for truck springs, 34,000 lbs.; camber 4½" free and 2" loaded; regulate capacity by number of plates whenever possible; slot preferred to stirrup; band, 2½" x ½" on top, ¾" on bottom; equalizers, solid bar with slotted ends.

109-121 Report on Tires, Thick or Thin ... **6 c**

Table showing wear after different turnings. Much variation.

126-132 Report on Prevention of Dangerous Escape of Live Coal and Sparks from Ash Pans ... **2 b**

Recommends designing of standard grates and ash pans, the latter of sheet iron with angle iron corners, ends of cast iron, with cast-iron dampers, machined to fit. Allow overflow to run into ash pan. Hollow stay bolts. Stringent rules. Drawings of 15 ash pans, one with an automatic damper which closes when steam pressure high.

132-142 Report on Tender Trucks ... **6 a**

Simply answers to questions.

143-148 Report on Traction Increasers in Connection with Over-Cylindered Engines. "They are no good." ... **6 c**

151-158 **Report on Cast Iron Wheels** ... **1 a**

Committee recommends specifications, tests, form of contract, and service guarantee, which are unanimously approved. (*See pages 151-154.*)

158-161 Topic: Air openings in smoke boxes. One man got good results by having an adjustable opening in bottom of extension (!) ... **6 b**

161 Topic: Feed-water heaters. By careful experiments on Reading Railway no advantage found ... **6 c**

162 **Resolution unanimously adopted "that it is the sense of the M. M. Association that pilots of all engines should have steps placed on the front end for safety and convenience of brakemen while coupling at the front ends** ... **1 a**

163-164 Topic: Water space around fire box ... **6 a**

Should be wide to give good circulation.

171-177 Paper on Boiler Steel. Its manufacture, etc ... **6 a**

1889

18-24 Topic: Cause of Burst Steam Chests ... **6 c**

28-36 **Report on Tires** ... **2 b**

"We recommend that tires 3" in thickness of the best quality of material would be the best and most economical for railroad purposes. [Page 36.]

37-53 Report on Driving and Engine Truck Boxes ... **3 c**

Cast steel for driving boxes objected to on account of poor wear, and it expands faster than the brass, making the latter loose when it becomes hot. [Page 38.] Bronze driving boxes recommended, but first cost high. Hexagonal brasses better than half-round, because they do not distort box, but require careful fitting. Composition for brasses given. No drawings. Strips of babbit one inch wide give good results in truck bearing.

54-66 Report on Best Boiler Covering ... **6 c**

Poorness of wood spoken of, but no recommendation.

66-91 Report on Driver Brakes ... **6 c**

Their use believed in. Some oppose them on account of wear of tires, breakage of rods, etc.

91-102 Topic: Axles for tenders of heavy capacity ... **3 c**

102-112 }
127-132 } **Report on Foundation Ring for Boiler Leg** ... **2 a**

"*Your committee recommend a double riveted foundation ring, substantially as shown in drawing No. 13, page 106.*"

112-127 Report on Best Proportion of Grate and Flue Area ... **6 a**

No conclusion, but opinions received given. In appendix is a paper on "Design of a Locomotive Boiler," in which the Belpaire is claimed to be the only *logical* form of boiler, giving reasons. "*Strong*" boiler praised.

1889

PAGE

132-143 **Report on Water Space Surrounding Fire Boxes and Flues of Locomotives. Is it usually large enough for free circulation?** .... **2 a**

From replies to committee there is almost a unanimous sentiment in favor of enlarging the water space between the fire-box sheets to 4" or 4½", and even 5". The general feeling is for ¾" spaces between 2" flues, which should be in a vertical line to cause less hindrance to circulation. Crown bars losing favor.

144-147 Report on Magnetic Influence of Iron and Steel in Locomotives on the Watches of Enginemen .... **6 c**

Influence very slight and does not amount to a serious disturbing element.

158-159 Discussion on Method of Securing False Valve Seats .... **6 c**

To prevent the false seat from jumping up and breaking, two members put screws, loose, in the corners.

152-158 Discussion on Relative Proportions of Cylinder and Stack Diameters... **6 c**

No conclusion.

1890

28-32 Topic: Best method of fitting bolts .... **6 a**

More common practice is to taper bolts (1/16" per foot) and use ring gauges so that machinist need not caliper the hole.

32-38 Topic: Is it safe to run a pony truck under the front end of fast express engines? .... **6 c**

Some prefer 4-wheel trucks, because less wear on 4 wheels than on 2, and because safer.

40 Resolution adopted to appoint committee to investigate standards. [Page 160, 1891.]

41-46 Report on Compound Locomotives .... **6 a**

The committee favor them. They give 13 points on what gains have followed compounding, and 7 points on what losses *are said* to have followed compounding.

69-88 Report on Efficiency of the Link as Compared with Other Valve Motions. Information on the various valve motions with drawings, and with indicator cards of Wilson motion. The committee state that they know of no better valve motion, more efficient for all-around work and general ability, than a well designed link with large bearing surfaces, etc.. **6 a**

96-109 **Report on the advantages and disadvantages of placing the fire box above the frames** .... **2 a**

Advantages: Larger grate area; more water space around fire box; more space for ash pan; rigid wheel base can be shortened. On account of high boiler, less wear to running gear. Eleven drawings of changes coming with fire box above frame.

109-127 Report on Relative Value of Steel and Iron Axles .... **6 b**

Gives opinion of members from which no conclusion can be made. Discussion divided.

131-141 Report on Exhaust Pipes, Nozzles and Steam Passages ....X **6 a**

Continued 1891, page 30.

141-154 **Report on Brick Arches** .... **2 a**

Page 146: Committee "recommend its use by all who desire to get the best and most economical results from bituminous coal." It assists in bringing about more perfect combustion and thus aids in lessening the amount of black smoke. "Evidence is overwhelmingly in favor of brick arch and extension front (outside of first cost) compared to short front and diamond stack. Angle iron and stud supports for brick arch preferable to circulating pipe."

154-158 **Report on Prevention of Corrosion of the Metal in Coal Space and on Top of Tenders, Caused by Wetting Coal** .... **2 a**

Page 158.—The committee is of the opinion, from information received, "that several coats of a superior metallic paint, allowed to become thoroughly dry and hardened before the tank is put to use, would prevent a great deal of this corrosion." Good drainage necessary.

159-167 **Report on Axles for Heavy Tenders. M. C. B. 60,000-lb. Axle Adopted. (4¼" x 8" Journal.)** Wrong axle shown on pages 183, 179 .... **1 a**

Corrected, 1892. (See also page 295, 1899.)

1891

24-29 **Topical Discussion: Can Steel be Flanged Safely at Other Than a Red Heat?** .... **2 a**

The very great importance of not working the steel at a *blue heat*, to prevent formation of small cracks, brought out. It is best to stop work at cherry red.

30-47 Report on Exhaust Pipes, Nozzles and Steam Passages ....X **2 b**

Shows drawings of nozzles experimented with, and some general recommendations made. [See 1896, page 58.]

48 63 Relative Value of Steel and Iron Axles .... **6 c**

No recommendation. Difference of opinion.

65-90 **Report on Testing Laboratories for Railways** .... **2 a**

Their organization and province. A very complete paper, with much valuable data.

1891

PAGE

97-119 Discussion on Compound Locomotives, mostly by builders .... **6 c**
Advantages of two and four cylinder types compared.

119-125 Report on Purification or Softening of Feed-water .... **6 c**
No recommendation. No successful ways. List of various methods tried.

126-132 **Report on Examination of Engineers and Firemen**.................... **2 a**
Gives advice to employers, including way to educate firemen.

133-139 Report on Operating Locomotives with Different Crews.................... **6 a**
Advantages and disadvantages, but no recommendations. Some points to make pooling successful.

139-158 Report on Locomotives for Heavy Fast Freight and Passenger Service.. **3 c**
Ten-wheel vs. moguls. Preference is for 10-wheel, but discussion divided.

160-163 **Report on Standards of the Association. Some thrown out as Standard but remain as the Recommended Practice of the Association**.. **1 a**

Standards:

1. United States screw threads.
2. Micrometer gauge for sheet metal.
3. Limit gauges for bar iron.
4. Gauges for driving-wheel centers and tire.

} Reaffirmed as standards.

Recommended Practice:

Axles for light and heavy tenders; tests and specifications for cast-iron wheels; journal bearing, journal box and pedestal; and allowance of six miles per hour to switch engines.

163-192 Report on Air Brake Standards, etc..**X 2 c**
Complete instructions; not adopted.

1892

19-98 Report on Compound Locomotives .... **6 a**
Details (and indicator cards) given of experiments with two Baldwin engines, C. M. & St. P., Class D, moguls, identical in every respect except compounding features. Economy of compound over simple found to be 16.9% coal and 14.1% water.

100-124 **Report on Tests of Iron and Steel** .... **2 a**
From experiments, of which details are given, they make six conclusions, of which the following is important: Steel should not be worked at a temperature between normal and a perceptible red heat [blue heat].

124-134 Report on Uniform Locomotive Performance .... **3 a**
Rules for making out performance sheets given, but they were not adopted on account of objections to some points.

135-149 **Report on Standard Bolts and Nuts. [See also page 290, 1899]**... **1 a**
Page 148: U. S. Standard sizes of nuts and bolt heads adopted. Also, adopted, that the Association urges rigid adherence to same, and deprecates use of over or under-sized bolts and nuts.

149-168 Report on Boilers for High-pressure Locomotives .... **6 a**
Examples of best practice given. Drawings of 8 boilers. Radial stay and Belpaire preferred to crown bar.

168-196 **Report on Air Brakes**...**X 1 a**
Air Brake and Signal Instructions, pages 170-195, adopted.

1893

22-53, 165-173 } Preliminary Report on Standard Tests of Locomotives...................**X 6 b**
Detailed account of testing locomotives. [1894, page 166.]

54-60 **Topical Discussion: Method of Fluting Side Rods** .... **2 a**
Majority favor machine work to forging. Forging leaves dents and fine cracks, which will grow, and more skilled labor required.

61-63 Discussion on Broken Cylinders... **6 a**
Causes spoken of.

63-67 Discussion on Broken Piston Rods .... **6 a**
Laird cross head causes much of this, especially if there is any vertical looseness, and small length of bearing.

68-87, 138-144 } Report on Tests of Iron and Steel...**X 3 a**
The employment of an expert examiner in addition to chemical and physical test, objected to in discussion. Bending test recommended, both nicked and unnicked pieces, to discover laminations, etc ....**X 2 a**

88-137 **Report of Committee on Compound Locomotives** .... **2 a**
Gives account of experiments made. Conclusions of committee, page 117: "The compound is suitable for a variable class of freight service." "In passenger service, its availability undetermined."

144-148 **Report on Wheel Centers and Tires.**
Outlines for flanged and plain tires adopted as standard, page 145.......... **1 a**
Standard wheel centers, 70", 74", 78", 82", 86" and 90", adopted. **[See also pages 293, 294, 1899.]**.. **1 a**

149-164 **Report on Boiler Attachments and How Their Safety Can be Increased** **2 a**
Eight recommendations made along this line, about location and construction of valves, with drawings. Nearly all very valuable (pages 151-154).

1893 **PAGE**		
	Discussion mostly on gauge cocks, with following resolution adopted (page 161): **" Resolved, That while the M. M. Association regard the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives "**	**1 a**
173-175	**Report on Malleable Iron Castings** *" There is no evidence to indicate the probability that malleable iron castings can be generally used as a substitute for expensive forgings. Now used as a substitute for gray iron castings or inexpensive forgings." List of parts given for which they can be used.*	**2 a**
175-184	Report on Attachments Between Engine and Tender, Foot-Steps and Hand-Rails Different practices given.	**6 a**
184-192	Report on Smoke Prevention Brick arch and steam jets spoken of as effective. Importance of careful firing brought out in discussion.	**6 a**
192-201	Discussion on Washing Out Boilers and Testing Stay Bolts. Members give their methods	**6 a**
201-205	Report on Tender Frames A summary of practices. 5 drawings of tender frames.	**6 a**
205-213	Paper on Locomotives in Argentine. Compares English and American locomotives there	**6 b**
1894		
25-36-56	**Report on Cracking of Back Tube Sheets** **From replies, committee states: High pressure radial stay boilers are most subject to cracked tube sheets, and the causes are twofold: Rigid staying of crown sheet near tube sheet, and placing flue holes too close to flange of tube sheet. Remedy: Use flexible crown sheet support at front end.** 8 drawings of sling stays. In discussion, following additional causes brought out: Excessive rolling, and tubes so close together that water is driven away from sheet. The damage mostly happens when firing up.	**2 a**
58-68	Report on Oiling Devices for Long Runs " Modern practice is to deliver a small amount of oil continuously over the whole length of bearing." Cups or oil pockets are solid, rather than separate. Grooves are liberal in number and size. The cheapest oil is then admissible. Strainers and covers over all oil pockets desirable. Methods of members given, with one drawing. Some oil specifications.	**6 a**
68-92	**Report on Boiler and Fire Box Steel Specifications** **Specifications (pages 68-78) adopted.**	**1 a**
92-102,216	Discussion on Compound Locomotives Experiences both ways given. Talks by builders.	**3 b**
102-108	Report on Fire Kindlers Details given of experiments to show crude oil is much cheaper than wood (Leslie fire kindler). No recommendation.	**3 b**
108-133	Report on Exhaust Nozzles and Steam Passages Conclusions from tests (pages 111, 112). Continued, 1896. Important. Experiments made with engine mounted on wheels. Tables given of results, and drawings of experimental nozzles, stacks, and apparatus.	**X 2 a**
133-145	Reports on Sanding Devices The ordinary sand lever arrangement poor compared to pneumatic. By latter, average saving in sand per year is $17.32 in one case, and in addition, reduced wear of tires, and also lessened resistance to trains. The result is strongly in favor of this method. Committee also recommends a tell-tale arrangement (yet to be designed) in the cab, as a reminder to the engineer, so as not to forget to shut off sand. Ventilating sand box recommended as shown in drawing, page 142.	**2 a**
146-166	Report on Special Shop Tools A general discussion, giving lines along which improvements can be made. Hoists for use at heavy machine tools. Small tools set in holders to prevent necessity of dressing. List of special shop tools, with names and addresses of members who can furnish prints and information about them (pages 153-159).	**6 a**
166-200	**Report on Standard Tests of Locomotives** Report as amended [page 200] made standard.	**1 a**
201-216	**Report on Tire Treatment** **Recommendations:** Page 206.— Retaining rings are necessary on wheel centers above 62" diameter. Page 207.— Do not run tires with retaining rings any thinner than without them. Page 207.— Use same shrinkage with retaining rings as without. Page 205.— Drawing of Mansell Ring Fastening. Page 209.— Minimum thickness of tires considered safe: Passenger, 1½" last turning. } Weight on drivers Freight and Switching, 1¼" last turning. } not to be considered.	**2 a**

1894
PAGE

Page 211.— Greatest permissible depth of wear of tires, ¼" on road engines, ⅜" for switch engines, but business conditions must govern.
Page 216.— Depth of flange permissible: road engine, 1½"; switch, 1⅝". Drawings of instruments for measuring wear of tire and flange.

227-243 **Report on Cost of Maintaining Locomotives**.......... **2 a**
Cost of maintenance of locomotives built in contract shops more than home-made ones. Tables given, C. B. & Q. experience. Locomotive repairs of one road can not be compared from totals with those of another, because of difference in items included, as shown in table, pages 238, 239. Means given by which cost of repairs may be reduced: Centralizing heavy repairs where work can be done cheaper. In conducting repairs keep in mind that the engine is not in service and losing money. To reduce this time a number of roads keep turned tires on hand, which are used, and old ones turned at leisure, without taking out wheels [page 240]. Same with many other parts, even a boiler [241]. Equip roundhouse properly for running repairs. List of required tools given.

1895

21-40 Report on Fire Kindlers.......... **2 b**
Page 22.—" That the oil kindler is past the experimental stage seems proven. There is no doubt of its efficiency. It saves labor and time, reduces fire risks, reduces hauling of fuel for kindling, and storing and hauling. Leslie kindler mostly used. Tables given showing comparison of wood and oil kindlers on various roads.

40-56 Report on Raising Funds for Shop Tests at Purdue, which are outlined.. **6 c**

56-67 Discussion on Swing Truck and Position of Blind Tire.......... **6 b**

71-98 Report on Causes of Bulging of Fire Box Sheets.......... **6 a**
Three causes [page 72]: (1) Accumulation of mud and scale, causing high heating of sheets: (2) insufficient water space, impeding circulation, which drives water off sheet; (3) bad water, which causes foaming and exposes sheets to fire.......... **6 a**
Diagrams showing difference of temperature on fire and water sides of sheets of different thicknesses, and decrease of strength and elastic limit with temperature. A remedy against incrustation, given in detail by a member, consists in precipitation in tender or boiler with chemical (composition not stated). Forms of pipes shown as used for washing boilers.

99-105, 123-127 } **Report on Best Material and Specifications for Boiler Tubes**....... **1 a**
(Page 102.) Specifications and tests for locomotive iron boiler tubes, extra quality. Adopted. See also **page 296, 1899.**

106-111 Discussion on stationary wedges.......... **6 a**
Very much favored.

112-122 Discussion on Compound Locomotives.......... **6 a**

130-143 Report on Shop Tests for Locomotives.......... **6 b**
Outline of proposed tests at Purdue.

144-150 **Report on Gauges for Sheet Metal, Tubes and Wire**.......... **1 a**
Elliptical notched decimal gauge adopted, the seven items in connection being given on **page 291, 1899.**

151-158 Report on Utilization of Railroad Scrap Material.......... **6 a**
Intelligent handling required, some points on which are given. Various uses that different kinds of scrap may be put to given.

158-178 Reports on Pistons, Piston Rods and Fastenings..........X **2 a**
Conclusions of committee [page 167]: For pistons of moderate diameter and for slow-speed engines there is an open choice between the bull-ring form and box form, while for pistons of any diameter, if for high-speed engines, the single plate type presents the important advantage of lightness combined with strength. [Continued 1896, page 202.]

178-228 **Report on Riveted Joints**.......... **2 a**
A valuable treatise, minute in detail. Joints in use critically considered. Tables for use in designing.

228-271 **Report on the Wear of Driving Wheel Tires**.......... **2 a**
Irregularities of wear considered, and diagrams showing it under different conditions of counterbalance, etc., as found in practice. Mathematical discussion by E. M. Herr. Observance of following recommended:

1st. Driving wheels should have ample weight for adhesion.

2d. Main rods should be as long as possible, as is consistent, in order to decrease effect of angularity.

3d. The weight of the reciprocating parts, and consequently the overbalance in the driving wheels, should be as light as possible.

4th. As small a proportion of the reciprocating parts should be balanced as is consistent with smooth-working machinery and good riding conditions.

5th. The driving boxes, shoes and wedges should be well maintained and kept properly adjusted.

6th. Have a careful and competent engineer in charge who will avoid slipping the tires.

1895

PAGE

272-274 **Paper on Uniformity in Computing Boiler-Tube Heating Surface**...... **2 a**

Gives good reasons why inside diameter of tubes should be used in figuring heating surface. Baldwin, Schenectady and Pittsburgh Locomotive Works, and P. R. R. figure on outside diameter, Rhode Island L. W. figure on inside diameter.

1896

58-148 **Report on Exhaust Pipes and Steam Passages**........................ **2 a**

Exhaustive experiments in reference to form and character of the exhaust steam jet, and the study of its efficiency as affected by all the various changes suggested on page 58. Conclusions in reference to jet on page 72 (11 headings).

Conclusions in reference to maximum efficiency, pages 134-136. The best arrangement is shown on page 136, for the engine experimented upon, and the changes which may be made without materially changing the efficiency are given on page 137. Stack recommended shown on plate 52, page 142 (tapered choke stack).

Profusely illustrated. To be discussed in 1897.

See 1897, page 91. Good results obtained by following recommendations. See 1899, page 62, more good results.

148-161 **Report on Counterbalancing**.. **2 a**

Practical and simple rules and methods which can be introduced into locomotive shop practice. Drawings showing apparatus required.

Rules (as reworded 1897, page 119):

1. Divide the total weight of the engine by 400; subtract the quotient from the weight of the reciprocating parts on one side, including the front end of the main rod.
2. Distribute the remainder equally among all driving wheels on one side, adding to it the weight of the revolving parts for each wheel on that side. The sum for each wheel, if placed at a distance from the driving-wheel center equal to the length of the crank, or a proportionately less weight at a greater distance, will be the counterbalance required. Found satisfactory on trial. [See 1897, page 117.]

161-200 **Report on Slide Valves**.. **2 a**

Rule for balancing: Area of balance = area of exhaust port + area of two bridges, + area of one steam port, for both plain and Allen valves (page 184).

Friction diagrams from practice, comparing balanced and unbalanced valves.

202-229 **Report on Reciprocating Parts**.. **2 a**

A discussion on the advantages and disadvantages of different designs and materials for pistons, showing drawings of good practice of light weight piston rods, cross heads, and main rods.

229-245 **Report on Cylinder Bushings**.. **2 a**

1. Cylinder bushings ½ inch to ¾ inch in thickness will meet all requirements.
2. The bushings should be turned to the same diameter as the cylinder fit.
3.. Bushings fitted as in Plates Nos. 1 and 2, without any fastening, except pressure of the heads, will give perfectly satisfactory results. (Page 232.)
4. The use of bushings is a practical method of reducing the bore of cylinders, of repairing cracked and worn cylinders, and avoiding the difficulty of cylinders which are too soft.
5. The question of fuel and economy, which may be obtained by the use of hard homogeneous bushings, is one which should receive careful attention.

245-257 **Report on Hub Liners**.. **2 a**

Review of practices, with drawings.

1. If a good system of interchange hub liners is in use, it is unnecessary to make use of box liners.
2. Cast iron is sufficiently good material for hub liners, and the use of brass or bronze is unnecessary.
3. Their application to all the wheels of new engines and to all wheels introduced under old engines, is good practice.
4. The use of loose liners, riding on axle between wheel hub and box, is not good practice.

258-265 **Report on Steam Pipe Joints**... **2 a**

Recommendations as to details, page 263.

In discussion it was brought out that the cast-iron plano-convex joints are much better than brass (recommended by committee), the iron and brass expanding unequally.

265-280 **Discussion on Radial Stay Boilers**.................................... **1 a**

Resolution unanimously carried, "that it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs."

282-302 Report on Apprentice Boy ....X **6 a**

Outline of school work, etc. (continued to 1897).

304-308 Report on Driving Wheel Wedges.. **6 a**

1896

PAGE

A summary of replies received, the majority (33 to 16) favoring fixed shoes.

308-313 Report on Locomotive Steps and Handholds .... **2 b**
Plans shown on pages 310 and 311 recommended.

313-325 Report on Truck Swing Hangers. [See 1897, page 123.] .... **6 b**

325-331 **Report on Thickness of Engine Truck Wheel Flanges** .... **1 a**
Recommendations: 1. The minimum thickness of leading engine truck wheel flanges should be the same for both iron and steel wheels.
2. The minimum thickness shall be 1 inch, measured at a point, ¾ inch from the top of flange, as shown on the appended diagram, Fig. 3, page 327, the standard flange thickness gauge of the M. C. B. Association to be used in making this determination.
Adopted as standard practice.

331-333 Report on Standard Size of Boiler Tubes .... **1 a**
Slight change adopted in standard to suit standard gauge.

333 Resolution carried "that it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of the ton-miles of train load, in lieu of train miles or loaded car miles, as is the prevailing practice today." [Compare 1899, page 173] ......X **1 a**

1897

69-75 Discussion on Piston Rods—Best Design and Material .... **6 a**
High carbon and nickel steels spoken of. Hollow and enlarged end at cross head.

75-91 Discussion on Compound vs. Simple Engines .... **6 a**
Saving in fuel 20% (C. M. & St. P.), etc.

97-117 Discussion on Report of 1896 on Exhaust Nozzles and Steam Passages.
Generally good results obtained by following recommendations. Same results, 1899, page 62.

117-123 Discussion on Report of 1896 on Counterbalancing; Supplementary Report.
Four roads tried recommendations and found them satisfactory.
Recommendation reworded on page 119 to correct ambiguity.

123-129 **Continued Report of 1896 on Truck Swing Hangers** .... **2 a**
Experiments made to measure side thrust on truck, and for the engine experimented on (page 124), the best results were 18° for 6⅜" hangers, and 28° for 8" hangers, converging upward. Drawing of machinery in detail. No general conclusions. Value of three point hangers not mentioned here, although drawing shown, 1896, page 321. No general conclusions.

130-166 **Report on Locomotive Grates, for Anthracite Coal. Thirteen advantages of shaking grates, page 144** .... **2 a**
"It appears in brief to your committee that a grate should be composed wholly of cast-iron shakers for fire boxes not over the drivers.
"For wide fire boxes, those extending over the drivers, using lump coal, transverse shakers alone, or longitudinal shakers lightened with water tubes between, are recommended.
"For wide fire boxes over the drivers using small coal, shakers appear to be preferable in whole or in part."
Every detail considered carefully, with many drawings. A valuable report.

166-187 Report on Apprentice Boy ....X**2 c**
Outlines of courses, night schools, etc. (Continued.)

188-190 Discussion on Cylinder Clearance .... **6 c**
Is the common large clearance economical? Conclusion: No.

190-192 Discussion on Use of Piston Valves for Simple Engines .... **6 a**
Advantages and disadvantages spoken of.

192-195 Discussion on "When Is It Permissible to Use Water on Bearing Surfaces of Locomotives?" .... **6 b**

195-197 Discussion on "Manual vs. Antomatic Control of Compound Features of Compound Locomotives." Divided discussion .... **6 b**

197-199 Discussion on "Causes of Irregular Wear of Cylinders of Locomotives Carrying High Steam Pressure" .... **6 b**

199-200 Discussion on "Lead for Passenger, Freight and Yard Locomotives".... **6 c**

200-203 " "Broken Stay Bolts" .... **6 a**
Drilling stay bolts recommended.

203-218 **Report on Best Metal for Cylinders, Valves and Valve Seats** .... **2 a**
Recommendations:
1. As a rule cylinders should be as hard as is consistent with machining requirements.
2. The matter of shrinkage should receive close attention in making cylinder mixtures.
3. Members having the facilities should make systematic tests of the hardness, shrinkage and strength of metal used in cylinder castings and supplement the same with chemical analysis.
4. The valves should be of cast iron.

Gives cylinder mixtures used on different roads. (20% steel on N. & W. with good results.) Cast iron wears best with tensile strength, 28,000 pounds to 32,000 pounds, a curve for which is shown on p. 213.

1897

PAGE

218-234 **Report on, The proper ratio of heating surface and grate area to cylinder volume for passenger and freight engines, whether burning anthracite or bituminous coal, and the ratio which should exist between the size of cylinder and length of steam port....... 2 a**
Conclusions:
1. Ratio of grate area in square feet to total cylinder volume in cubic feet should not be less than 4 for large anthracite coal, 9 for small anthracite, 3 for bituminous coal, for simple locomotives.
2. The ratio of heating surface in square feet to total cylinder volume in cubic feet should not be less than 180 for large and 200 for small anthracite coal, and 200 for bituminous coal, for simple locomotives.
3. The ratio of heating surface to grate area should not be less than 40 for large and 20 for small anthracite coal; 60 for bituminous coal. Other ratios also given. Various tables and formulæ of value.

234-241 **Report on Boiler Jackets .... 2 a**
Committee concludes "that it is more economical to use boiler jackets of common sheet iron, or sheet steel painted, than it is to use jackets of planished iron."

241-259 **Report on Piece Work in Locomotive Repair Shops .... 2 a**
Committee "most heartily recommends its adoption," giving reasons (pages 244, 245). Advice and experiences in discussion.

260-273 **Report on Motors, Steam, Air and Electric .... 2 a**
For general railroad work, with the exception of special cases spoken of, a well-designed air plant will be the most convenient and economical, all things considered.
Uses, cost, and various details given.

273-298 Report on Air Brake and Signal Instructions ....X **6 c**
Continued to make additional revisions.

298-304 Paper on Application of Electricity to Steam Railroads.................. **6 a**
Good thing, especially in special cases.

1898

52-86 **Report on Tonnage Rating for Locomotives............................ 2 a**
Valuable rules, curves and examples, with practices of different roads, considered in detail. A good guide for further work.

87-99 **Report on Best Methods of Boiler and Cylinder Insulation .... 2 a**
Different laggings experimented on in laboratory. Magnesia found to be best non-conductor. Curves showing results. Drawings of methods of applying cylinder lagging and removable lagging over stay bolts.
Committee decidedly of the opinion that economical results will follow the use of good non-conducting material on all radiating surfaces where the estimated economy will not be overcome by the inconvenience and expense of removing same for repairs (page 90).

99-103 Discussion on Special Apprentices.. **6 a**

103-108 " " Is it possible to arrange the front ends of locomotives so they will clear themselves of cinders without throwing sparks .... **6 a**
Experiences given, and drawings of self-cleaning smoke boxes.

108-114 Discussion on railway mechanical engineering in technical schools. What should be taught discussed .... **6 a**

120-126 Report on Advantages of Improved Tools for R. R. Shops.............. **6 a**
This not taken advantage of as it should be.
Milling machines, turret lathes, light high speed shapers and planers, shop cranes, etc.

127-159 Report on Efficiency of High Steam Pressure for Locomotives........... **6 a**
Increase of pressure and locomotive repairs. Laboratory tests under different steam pressures. Boiler pressure vs. boiler capacity. High pressures increase economy, but good designing necessary or repairs will be great. Piston valve for high pressure.

160-187 **Report on Best Form of Fastening for Locomotive Cylinders......... 2 a**
Strains which must be resisted given under six heads. Plain statements and drawings.

188-194 Discussion on Use of Steel in Locomotive Construction .... **6 a**
Cast steel coming into use on account of lightness of parts, and cheapness when used in place of forgings.

194-198 Paper on Applications of Electricity to Steam Railroads.
Advantages and successes of electricity.

201-233 **Report on Revision of Air Brake and Signal Instructions .... 1 a**
Adopted (pages 201-228).

233-252 **Report on Apprentice Boy... 1 a**
Code of rules (pages 234-241) adopted, to be modified, however, to suit the variable conditions.

1899

59-62 Discussion on Metal Flexible Joints vs. Rubber Hose........ .... **6 a**
In favor of metal, although more first cost.

62-66 Discussion, To what extent and with what success have the recommendations of the committee on Exhaust Nozzles and Steam Passages

1899
PAGE

been adopted? The replies to the member who opened the discussion indicate that the practice is becoming almost universal, however with some slight modifications or alterations in different sections of the country to meet local conditions. Softer exhaust by that arrangement.

66-71 Topical discussion resulting in following .... 1 b

Moved and carried, "that it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order."

71-73 Topic: "When double-headers are used on passenger or freight trains, is it not good practice to cut out the brakes on the head engine, and does this comply with the requirements of the law?" .... 2 a

Nothing said about the law. Yes, for first part.

74-86 Report on Research Laboratory Under the Control of the Association... 6 c

Continued for further consideration.

93-124 **Report on, The Best Methods of Preventing Trouble in Boilers from Water Impurities .... 2 a**

Recommendations, pages 112-114: Find best source of water; be careful in using the so-called purifiers on the market; it generally pays to purify water; lime and soda ash are the cheapest of the effective and harmless reagents for this purpose, and direct treatment in the tender is the least costly method; blow-off cocks, etc.

124-147 **Report on Relative Merits of Cast-iron and Steel-Tired Wheels for Locomotive and Passenger Car Equipment .... 2 a**

Recommendations:

For engine trucks use steel-tired wheels from considerations of safety. Cast-iron wheel service is cheaper than that obtained from steel-tired wheels. Use at least the following method for determining mileage: Page 127.—"Make record, for example, of all tenders running with 33-inch cast-iron wheels; also of all wheels removed from these tenders during the year; obtain the mileage of these tenders for the same period and multiply by eight to obtain the total wheel mileage; divide this sum by the number of wheels removed, and the result will approximate closely with the actual wheel mileage obtained. While this method omits many details of importance, it gives actual results as a whole, and is much better than no information whatever." A careful record of breakages should be inaugurated and maintained (page 128). In discussion first recommendation objected to on account of insufficient data for its establishment.

148-150 Topic: Can the ordinary marine salinometer be used to advantage in districts where alkali water has to be used in order to avoid excessive concentration and damage to fire box .... 6 c

Not favored.

150-153 **Topical Discussion on fusible plugs resulting in the following motion, which was carried: "It is the sense of the A. R. M. M. Association that the use of fusible plugs in the crown sheets of locomotive fire boxes is not conducive to the prevention of the overheating of the crown sheet" .... 1 a**

153-160 Topic: Advantages of piston rods extended through front head. Opinions for and against them. Details not satisfactory yet. Some recommend them for pistons above 24 inches, some above 19 inches.

162-181 **Report on Advantages of the Ton-Mile Basis for Motive Power Statistics.** (Committee continued) .... 1 a

Page 173: Resolution carried, "That it is the sense of the Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements.

184 Professor Hibbard's resolution about appointing committee to find out to what extent the recommendations of this Association have been put into practice. (Carried.)

185-202 **Report on Best Method of Applying Stay Bolts to Locomotive Boilers. 2 a**

Recommendations, pages 191-192, giving operations in detail, including manufacture of stay bolts.

202-219 Report on Flanged Tires .... 6 a

Is it desirable to have flanged tires on all the drivers of moguls?

No recommendations. Committee continued. Their experiment made by *hauling* a consolidation engine on sharp curves is favorable to all flanged tires.

220-235 Report on Nickel Steel .... 6 a

Compilation of information, with references

235-272 **Report on Square Head Bolts and Nuts and Standards for Pipe Fittings. Page 237: Brigg's standard wrought iron pipe threads adopted for wrought iron pipe and couplings .... 1 a**

[See also page 298, 1899.]

1899

PAGE		
273-276	**Topical Discussion. "What can be done to thoroughly relieve the vacuum in the low pressure cylinder in a compound engine when drifting?" By-pass valve highly favored. Relief valve troublesome from leakage, etc**	2 a
276-277	Moved and carried "that it is the sense of this Association that **it is not desirable to use Bars in Exhaust Nozzles."**	1 a
277-280	Topical Discussion. "Is there sufficient prospective economy to be derived from heating the feed-water for locomotives and how can it be most reliably fed to boilers?" Divided discussion	3 a

REPORT OF COMMITTEE ON THE EXTENT TO WHICH THE RECOMMENDATIONS OF THE ASSOCIATION HAVE BEEN PUT INTO PRACTICE.

To the President and Members of the
American Railway Master Mechanics' Association:

Your committee appointed at the Old Point Comfort Convention in June, 1899, to ascertain "The Extent to Which the Recommendations of the Association Have Been Put Into Practice," begs leave to submit the following report:

As a preliminary to this report, your committee sent out a letter of inquiry, dated February 28, 1900, accompanied by an alphabetical and classified index of all the subjects dealt with in the reports, papers and discussions, during the thirty-two years of the Association's existence. These indices are thought to be of permanent value to members of this Association and are, therefore, included as part of the final report of your committee. As a result of this letter of inquiry sent to upward of six hundred members, your committee only received four replies and, therefore, prepared a second circular of inquiry, which was sent out under date of April 30, 1900. At the date of this writing your committee has received 25 replies to the circular sent out and the 77 questions propounded have been replied to by most of those sending in answers. In order to record for the members the form in which the questions were put, we reprint herewith the greater part of this second circular of inquiry and append after each question a summary of the replies received.

In advance it may be stated that in round numbers the total number of circulars or inquiries sent out was six hundred. The total number of individuals making replies was 25, the number of different railroads represented in the replies was 23, and the number of locomotives owned by the roads represented in the replies was 7,764. The number of locomotive builders represented in the replies was 1 and the number of Mechanical Engineers and others not in railroad business making replies was 1.

Your committee does not feel that from so small a number of answers out of so large a membership it would be proper to draw final or affirmative conclusions, but certain negative conclusions can at least be drawn. It is found that the recommendations of the Association have been unanimously approved by those answering this circular in only 7 cases. They have been approved with a small minority against it in 27 cases. They have been disapproved by a large minority and in some cases even a large majority in 32 cases, while in the remaining 12 cases the opinion is too varied to classify.

Respectfully submitted,

F. A. DELANO, Chairman.
A. SINCLAIR,
H. MIDDLETON,
Committee.

CHICAGO, ILL., June 2, 1900.

QUESTIONS IN DETAIL ASKED BY THE COMMITTEE APPOINTED TO ASCERTAIN "THE EXTENT TO WHICH THE RECOMMENDATIONS OF THE ASSOCIATION HAVE BEEN PUT INTO PRACTICE,"

AND A

SUMMARY OF THE REPLIES RECEIVED.

Recommendations as to standard nuts, screw threads, bolts, bolt heads and bar iron.

(1) On the subject of STANDARD NUTS, STANDARD SCREW THREADS, BOLTS, BOLT HEADS and STANDARDS FOR BAR IRON it will be noted that:

In 1870 the Association recommended the formal adoption of the U. S. Standard nuts.

In 1884 adopted Pratt and Whitney limit gauges for round iron to be used for Sellers' standard thread taps.

In 1891 reaffirmed formally the standards of 1870 and of 1884.

In 1892 adopted the standard U. S. Standard sizes of nuts and bolt heads and urged on the members of the Association a rigid adherence to the same.

In 1899 Briggs' standard wrought iron pipe threads were adopted for wrought iron pipe and couplings as standard.

Your committee would ask the following questions:

Q. 1. Do you follow strictly the U. S. Standard for sizes of nuts and bolt heads?

A. 25 replies were made to this question, all of which were "Yes."

Q. 2. Do you follow Pratt and Whitney limits for round iron?

A. 20 replies were made to this question, 16 of which were "Yes" and 4 were "No."

Q. 3. U. S. Standard threads?

A. 25 replies were made to this question, all of which were "Yes."

Q. 4. Do you conform to Briggs' Standard wrought iron pipe threads for wrought iron pipes and couplings?

A. 24 replies were made to this question, 21 of which were "Yes" and 3 were "No."

Recommendations as to boiler construction.

(2) On the general subject of BOILER CONSTRUCTION, the Association has made a good many recommendations, namely:

In 1871 it recommended steam as better than hand riveting.

In 1872 recommended all holes in longitudinal seams be drilled and made to match by reaming rather than by the use of a drift pin; also that hollow stay bolts be used.

In 1881 recommended machine riveting, especially steam riveting.

In 1885 recommended making a clean metallic joint between surfaces to be calked with waste wet with a weak solution of sal ammoniac and hot water.

In 1885 that in hydraulic tests for locomotives, hot water 25 pounds above working pressure be used.

In 1889 recommended the double riveting of the foundation or mud rings on boilers.

In 1894 drew up specifications for boiler and fire-box steel.

In 1895 approved a report showing best methods of making a riveted joint and best designs therefor.

In 1899 approved a report on best method of applying stay bolts to boiler.

Your committee asks ten questions in connection with these recommendations, as follows:

Q. 5. Are you using steam or machine riveting in preference to hand riveting?

A. 23 replies were made to this question, 11 of which were "Yes," 5 of which were "No" and 7 were doubtful or mixed.

Q. 6. Do you drill longitudinal seam holes?

A. 23 replies were made to this question, 13 of which were "Yes" and 10 were "No."

Q. 7. Do you use reamers instead of drift pins?

A. 21 replies were made to this question, 19 of which were "Yes" and 2 were "No."

Q. 8. Do you use hollow stay bolts?

A. 25 replies were made to this question, of which 5 were "Yes" and 20 were "No."

Q. 9. Do you clean off joints of boilers with sal ammoniac and water to make close joints between lapped seams?

A. 23 replies were made to this question, 1 of which was "Yes" and 22 were "No."

Q. 10. Do you use hot water hydraulic pressure 25 pounds in excess of working steam pressure to test boilers?

A. 22 replies were made to this question, 20 of which were "Yes," 2 stated that test pressure used was from 40 to 50 pounds in excess of boiler pressure.

Q. 11. Do you double rivet foundation or mud rings?

A. 23 replies were made to this question, 17 of which were "Yes," 1 was "No" and 5 were "Yes" with qualifications: e. g., "high-pressure boilers," "new work only."

Q. 12. Do you follow the specifications recommended on pages 68 to 78 (1894) for boiler and fire-box steel?

A. 20 replies were made to this question, 10 of which were "Yes," 2 were "No," and 8 said "Only partially."

Q. 13. Do you observe the recommended practice and designs for riveted joints of boilers?

A. 20 replies were made to this question, 10 of which were substantially "Yes," 3 were "No," and 7 said "Partially."

Q. 14. Do you follow recommendations (pages 191 and 192, 1899 report) for applying stay bolts?

A. 21 replies were made to this question, 17 of which were "Yes," 2 were "No," and 2 say "Partially."

Recommendations as to use of sling stays.

As bearing further on this subject in 1880, the Association passed on the subject of the use of SLING STAYS and decided:

In 1880 that in crown bar boilers it was essential to use sling stays from the crown bars to the outside shell of the boiler.

In 1894 it was recommended that in view of the greater breakage of flue sheets in radial stay boilers, due to the rigid strain of the crown sheets and placing of flues too close to the flange of the sheet, that flexible sling stays should be used to support the crown sheet at the front end.

In 1896 it was resolved as the sense of the meeting that a radial stay boiler was as safe as a crown bar boiler and more easily and economically kept clean and in repair.

Your committee asks the following questions:

Q. 15. Do you use sling stays from the crown bar to the outside shell of boiler in crown bar boilers?

A. 24 replies were made to this question, 22 of which were "Yes" and 2 were "No."

Q. 16. Do you use sling stays at front end of crown sheet on radial stay boilers?

A. 24 replies were made to this question, 22 of which were "Yes," 1 was "No" and 1 was "Partially."

Q. 17. Do you find that radial stay boilers are as safe as crown bar boilers; also more easily kept clean and more economical to keep in repair?

A. 25 replies were made to this question, 24 of which were "Yes," the other "Yes" with certain qualifications.

ecommenda-
ons as to
iler tubes or
ies.

Bearing on the general subject of boiler construction, some recommendations in regard to BOILER TUBES or FLUES have been made.

In 1886 a committee reported on the best plan of removing, cleaning and resetting boiler tubes, and it was voted as the sense of the meeting that it was unnecessary to bead the front end of flues.

In 1889 a committee reported that it was almost the unanimous sentiment of the Association that the water space around the fire box should be from four to five inches; that the water bridge between flues should be ¾ inches, with 2-inch flues, and that the flues should be set vertical, so as to allow better circulation.

In 1895 specifications and tests were offered and adopted for boiler tubes. (See also page 296, 1899.)

In 1895 (again) the question was discussed as to a uniform method of computing boiler tube heating surface. Three locomotive works and the Pennsylvania Railroad reported that they figured the heating surface by figuring the outside diameter of tubes, whereas one locomotive works figures the heating surface by figuring the inside diameter of tubes.

In 1896 a slight change was made in the standard size to suit standard gauge. In relation to these recommendations your committee desires to ask the following questions:

Q. 18. Do you make it a practice of beading flues in front end of engine or not?

A. 25 replies were made to this question, 8 of which were "Yes," 14 were "No" and 3 were "Partially."

Q. 19. What do you consider the minimum water space allowable around fire boxes?

A. 25 replies were made to this question: 8 replied 4 inches, 1 replied 4½ inches, 16 make different replies, varying from 3 to 3½ inches on the side and back up to from 4 to 5 inches at front of fire box.

Q. 20. What do you consider the minimum water bridge of flues of various diameters?

A. 24 replies were made to this question: 13 replied ⅝ inch, 2 replied from ⅝ to ¾ inch, 5 replied ¾ inch, 1 replied ⅞ inch, and 3 say it depends on the quality of water, number and length of tubes, agreeing, however, that ⅝ inch is minimum for 2 inch tubes.

Q. 21. Do you set your flues in diagonal rows or vertical rows?

A. 22 replies were made to this question: 11 replied "Diagonal rows," and 11 replied "Vertical rows."

Q. 22. Do you follow the 1896 and 1899 specifications and tests for boiler tubes and the 1896 standard sizes?

A. 22 replies were made to this question: 11 replied "Yes," 7 replied "No," and 4 replied "To some extent."

Q. 23. Do you compute the heating surface by figuring the inside or outside diameter of tubes?

A. 21 replies were made to this question: 17 replied outside diameter and 4 replied inside diameter.

Standards for tank and car axles.

(**3**) Referring to the subject of STANDARD TANK AND CAR AXLES —

In 1879 the Association adopted the 3¾ by 7 inch journal for cars and tender axles of 40,000 pounds capacity.

In 1881 this was reaffirmed.

In 1890 adopted the M. C. B. 60,000-pound axle with 4¼ by 8 inch journal for heavy tenders.

In 1891 these recommendations were reaffirmed as recommended practice.

Q. 24. As these axles are also M. C. B. standard, your committee simply wishes to ask if you are using any other than M. C. B. standard axles for cars and tenders?

A. 22 replies were made to this question, 6 of which were "Yes," 12 were "No," 3 replied "Not as to new construction," and 1 replied that 4 by 7 inch and 5½ by 10 inch journals are also used.

Side rods.

(**4**) Referring to the subject of SIDE RODS —

In 1882 the Association favored the "I" beam section of side rod.

In 1884 approved formulæ offered by Mr. F. W. Dean for design of such sections.

In 1893 favored the manufacture of fluted or "I" beam side rods by machine work rather than by forging them out.

Your committee desires to ask:

Q. 25. Do you use "I" beam side rods in preference to rectangular section?

A. 25 replies were made to this question, 21 of which were "Yes," 3 were "No," and 1 replied "Partially."

Q. 26. Are these machined out or forged?

A. 24 replies were made to this question, 20 of which replied "Machined," 3 replied "Forged" and 1 said "Both ways."

Standard gauges for wire, tubes and sheet metal.

(5) On the subject of WIRE GAUGES FOR WIRE, TUBES AND SHEET METAL —

In 1882 the Association adopted the Brown & Sharpe micrometer gauge, which was reaffirmed in 1891.

In 1895 adopted an elliptical notched decimal gauge. (See also page 291: 1899.)

Your committee desires to ask:

Q. 27. Are you using the Brown & Sharpe micrometer decimal gauge; also the notched gauge?

A. 23 replies were made to this question, 9 of which were "Yes," 8 were "No," and 6 replied "Partially only."

Q. 28. Are you ordering sheet metal by the decimal gauge system or by some other, and if so, what?

A. 23 replies were made to this question, 12 of which were "Yes," 9 were "No," and 2 replied "Both decimal and B. W. G." Of those answering "No," 4 use B. W. G. and 3 use the so-called U. S. S. gauge.

Standard width between backs of wheels.

(6) Under the general heading of the GAUGE OF WHEELS ON AXLES FOR STANDARD GAUGE TRACK —

In 1884 the Association adopted 4 feet 5⅜ inches as the standard width between backs of wheels for tender trucks and locomotive wheels with the limits of 4 feet 5¼ inches, and 4 feet 5½ inches. These conform with the M. C. B. standard.

Your committee desires to ask:

Q. 29. Do you comply with these standards?

A. 23 replies were made to this question, 22 of which were "Yes," 1 "No."

Standard tire section, driving wheels, centers and forms of tires.

(7) Under the general heading of STANDARD DIAMETERS OF DRIVING WHEELS and the question of TIRES FOR DRIVING WHEELS, the Association has taken the following action:

In 1886 certain standard diameters of wheels and standard sections of tire were adopted, varying from 38-inch to 66-inch diameter, inclusive.

In 1877 a further report on this matter with the exact inside diameters of tires was adopted and the M. C. B. standard tire section also adopted.

In 1893 standard outlines for flanged and plain tires were adopted, and standard sizes of wheel centers from 70-inch to 90-inch were also adopted. (See also pages 293 and 294, 1899.)

Your committee desires to ask:

Q. 30. Do you use the tire section recommended by the Association and afterward adopted by the M. C. B. Association?

A. 25 replies were made to this question, 23 of which were "Yes," 1 "No," and one who says "No as to contour."

Q. 31. Are you using the standard driving-wheel diameters, recommended and approved by the Association?

A. 25 replies were made to this question, all of which were "Yes."

Wear of tires.

The Association has also discussed the question of WEAR OF TIRES.

In 1887 decided that the manipulation of the sand and handling of the brakes by engineers had a great deal to do with the wear of tires.

In 1895 an elaborate report on the wear of driving-wheel tires was submitted showing six different causes.

Counterbalance.

In 1896 the question of COUNTERBALANCE was considered and its relation to driving-wheel tires pointed out.

In 1896 (again) a report was submitted pointing out the best design for reciprocating parts in order to reduce the weight of counterbalance as much as possible.

Your committee wishes to ask:

Q. 32. To what extent the recommendations of the Association have been adopted; and what, if anything, has been accomplished in diminished wear of driving-wheel tires?

A. 17 replies were made to this question: 2 replied "Yes," 1 "No," and 14 replied "Partially."

Tire treatmen

In 1894 a report on tire treatment made the following recommendations:

Page 206. Retaining rings are necessary on wheel centers above 62 inches diameter.

Page 207. Do not run tires with retaining rings any thinner than without them.

Page 207. Use same shrinkage with retaining rings as without.

Page 205. Drawing of Mansell ring fastening.

Page 209. Minimum thickness of tires considered safe: Passenger, 1½ inches, last turning; freight and switching, 1¼ inches, last turning. Weight on drivers not to be considered.

Page 211. Greatest permissible depth of wear of tires: ¼ inch on road engines, ⅜ inch for switch engines, but business conditions must govern.

Page 216. Depth of flange permissible: Road engine, 1½ inches; switch, 1⅝ inches.

Drawings of instruments for measuring wear of tire and flange.

Q. 33. Are you following the first?

A. 21 replies were made to this question, 8 of which were "Yes," 8 were "No," and 5 replied "Partially or not strictly."

Q. 34. Are you following the second?

A. 16 replies were made to this question, 9 of which were "Yes," and 7 were "No."

Q. 35. Are you following the third?

A. 12 replies were made to this question, 8 of which were "Yes," 3 were "No," and 1 used no retaining rings.

Q. 36. Are you working to the limits for thickness of tires recommended by the committee?

A. 23 replies were made to this question, 14 of which were "Yes," — 3 being with special exceptions, and 9 were "No."

Q. 37. Are you permitting driving tires to be grooved deeper than ¼ inch for road and ⅜ inch for switch engines?

A. 22 replies were made to this question, 3 of which were "Yes" and 19 were "No."

Q. 38. Are you letting flanges get as long as 1½ inches for road and 1⅝ inches for switch engines?

A. 24 replies were made to this question, 10 of which were "Yes" and 14 were "No."

portions of
inders.

(8) Under the general heading of RELATIVE PROPORTIONS OF CYLINDER TO BOILERS AND GRATE AREA, the Association has made several recommendations.

In 1887 a formula for the proper proportions of locomotive cylinders was offered. (See page 43.)

In 1888 recommendations giving limits for these proportions were offered and approved.

In 1897 a report was made giving valuable data as to the proper ratios of heating surface, grate area and cylinder volume for passenger and freight service, burning anthracite or bituminous coal.

Your committee wishes to ask:

Q. 39. Are the formulæ above mentioned being followed by you in your locomotive practice and design?

A. 17 replies were made to this question, 7 of which were "Yes," 5 were "No," and 5 replied "To some extent only."

Q. 40. If not, are they simply ignored, or are they thought to be erroneous?

A. 12 replies were made to this question, 10 of which say they are following the recommendations in part and 2 ignored them on account of modified conditions.

(9) On the general subject of a MORE ECONOMICAL COMBUSTION, the Association has taken the following action:

haust
zles.

In 1881 comparatively high exhaust nozzles were recommended as the best practice.

tension
nts, brick
hes, form of
ck, etc.

In 1888 the conclusion of a committee reporting on the subject of extension fronts, brick arches, etc., concluded that brick arches were an excellent thing, but should not come closer than 1 inch from the side sheet or 2 inches from the flue sheet; that 90 pounds of coal per square foot of grate area per hour was about the maximum economical rate of combustion.

In 1890 another committee on brick arches stated that the evidence was overwhelming in favor of the brick arch and extension front end. Angle irons and studs for brick arches were preferred to circulating pipes.

In 1896 and 1897 a committee offered a very complete report on the proper height of exhaust nozzle and form of stack, recommending a tapered choke stack.

In 1899 the Association decided by vote that it was not desirable to use bars in the exhaust nozzle.

In relation to these recommendations, your committee desires to ask the following questions:

Q. 41. Do you use an exhaust nozzle as high or higher than the center row of flues?

A. 25 replies were made to this question, 14 of which were "Yes," 8 were "No" and 3 replied "Both higher and lower."

Q. 42. Do you use a brick arch, and if so, what clearance do you give from the side sheet and flue sheet?

A. 25 replies were made to this question, 16 of which were "Yes" and 3 were "No." Those answering "Yes" stated that clearance from front tube sheet is from 1 to 6 inches, 3 to 4 inches being the favorite dimension, with no clearance at side sheets. 6 gave doubtful replies.

Q. 43. Do you support the brick arch on angle irons and studs or on circulating pipes?

A. 22 replies were made to this question, 6 say "Angle irons," 7 say "Circulating pipes" and 5 say "Both angle irons and circulating pipes." 4 say "Studs only."

Q. 44. Do you use a tapered choke stack?

A. 24 replies were made to this question, of which 21 were "Yes," 2 were "No" and 1 "Both."

Q. 45. Do you use a single exhaust nozzle without a bar across it?

A. 24 replies were made to this question, 18 of which were "Yes," 4 were "No," and 2 say "Both single nozzle without bar and double nozzle."

(10) Report of TESTING LABORATORIES FOR RAILWAYS.

Testing laboratory.

In 1891 a very complete report was submitted on the subject of testing laboratories for railways, showing their proper organization and province.

In this connection your committee desires to ask:

Q. 46. Does your road have a testing laboratory?

A. 24 replies were made to this question, 9 of which were "Yes," 14 were "No" and 1 says "On a small scale."

Q. 47. Are the lines laid down by the above report followed or not?

A. 11 replies were made to this question, 4 of which were "Yes," 6 were "No" and 1 was "Not strictly."

(11) On the general subject of TESTING MATERIALS—

Temperature of steel.

In 1892 the Association accepted a report making six conclusions, the most important of which was that steel should not be worked at a temperature between normal and a perceptible red heat known as "blue heat."

In 1896 the Association again decided that it was of great importance in flanging steel that it should not be worked below a cherry red heat.

Your committee desires to ask:

Q. 48. Are the recommendations of the Association not to work steel in flanging at a blue heat being observed?

A. 23 replies were made to this question, all of which were "Yes."

Treatment of employes.

(12) Under the general heading of TREATMENT OF EMPLOYES, the Association has taken the following action:

In 1886 a resolution was passed that the Association deprecates giving testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry.

In 1891 a report was submitted giving advice to employers as to the best method of examining engineers and firemen, including suggestions on the education of firemen.

In 1898 a report was submitted on the subject of apprentice boys and a code of rules adopted by the Association to govern their promotion.

Your committee wishes to ask:

Q. 49. Have any or all the above recommendations been followed?

A. 18 replies were made to this question, 16 of which were "Yes, but in part only," and 2 were "No."

Availability of compound locomotives.

(13) Under the general topic of COMPOUND LOCOMOTIVES—

In 1893, the Association decided that the compound is suitable for freight service, but that its availability in passenger service was undetermined.

Use of by-pass valve.

In 1899, the Association decided that a by-pass valve to relieve the vacuum in the low-pressure cylinder when drifting was very important.

Your committee desires to ask:

Q. 50. Do you agree with the conclusions of 1893 in regard to compounds?

A. 20 replies were made to this question, 11 of which were "Yes" and 9 were "No."

Q. 51. Do you favor a by-pass valve to relieve the vacuum in low-pressure cylinders?

A. 15 replies were made to this question, of which 12 were "Yes" and 3 were "No."

Use of water glass.

(14) Under the general subject of STANDARDS FOR BOILER ATTACHMENTS, the Association—

In 1893 listened to a report making eight recommendations looking to increased safety, and adopted a resolution that the water glass, although a convenience and an additional precaution against low water, was not absolutely necessary to the safe running of locomotives.

Your committee desires to ask:

Q. 52. Do you agree with this resolution of the Association?

A. 23 replies were made to this question, of which 19 were "Yes" and 4 were "No."

Tonnage rating.

(15) Under the heading of TONNAGE RATING FOR LOCOMOTIVES and TON-MILE BASIS FOR STATISTICS, the Association—

In 1898 considered favorably a report on tonnage rating, and in 1899 adopted a resolution that it was the sense of the meeting that the ton-mile basis for motive power statistics is the more practical and encourages economical methods of operating, etc.

Your committee desires to ask:

Ton-mile basi for statistics.

Q. 53. Are you using the tonnage rating and ton-mile basis for motive power statistics?

A. 21 replies were made to this question, of which 18 were "Yes" and 3 were "No." Of those replying "Yes," 4 say "Yes, partially."

Specifications for chilled wheels servic guarantee, mileage recor

(16) Under the general heading of Chilled Cast-Iron vs. Steel-Tired Wheels for Cars and Locomotives —

In 1888 the Association approved specifications submitted by a committee for the manufacture of chilled wheels, giving a test, form of contract and service guarantee.

In 1899, in a report on the relative merits of cast wheels and steel-tired wheels for locomotive and passenger cars, a recommendation (see page 127) was made as to the best method of keeping a record of the mileage of wheels.

Your committee desires to ask:

Q. 54. Are you following the approved specifications, test, form of contract and service guarantee in purchasing wheels?

A. 18 replies were made to this question, of which 13 were "Yes" and 5 were "No."

Q. 55. Are you using the method suggested by the committee of 1899 for recording the mileage of wheels?

A. 18 replies were made to this question, of which 6 were "Yes" and 10 were "No," while 2 say "Yes for cast-iron chilled wheels, but not for steel-tired wheels."

Cylinder bushings, cylinder and valve metal.

(17) On the general subject of the Best Metal for Locomotive Cylinders and Cylinder Bushings the Association has taken the following action:

In 1896 accepted a report on cylinder bushings, making five distinct recommendations.

In 1897 accepted a report of a committee making four recommendations in regard to best metal to be used for cylinders, valves and valve seats.

Your committee desires to ask:

Q. 56. Do you use bushings extensively?

A. 21 replies were made to this question, of which 6 were "Yes" and 15 were "No."

Q. 57. Do you use bushings on new engines?

A. 23 replies were made to this question, of which 1 was "Yes," 21 were "No" and 1 says "On passenger engines only."

Q. 58. Do you find that you can make bushings of harder metal than you can get in cylinders?

A. 15 replies were made to this question, of which 9 were "Yes," 4 were "No" and 2 are "undecided."

Q. 59. Are you following the recommendations of the committee as to the best grade for cylinder iron?

A. 14 replies were made to this question, of which 7 were "Yes," 6 were "No," and 1 replied "In part only."

(**18**) Under the general heading of LOCOMOTIVE STATISTICS —

Mileage statistics.

In 1872 the Association adopted a report fixing an arbitrary mileage to be computed for switch engines at six miles per hour of actual service, for local freight engines 6 per cent for switching, and also that new engines to replace vacant numbers should be charged to repairs, except any excess in cost over the old ones.

Your committee desires to ask:

Q. 60. Are these rules being followed?

A. 18 replies were made to this question, of which 11 were "Yes" and 6 were "No," and 1 says "Sometimes."

(**19**) Your committee desires also to ask the following questions on various rather MISCELLANEOUS SUBJECTS which have been dealt with by the Association:

Flange thickness, truck wheels.

Q. 61. Are you following the rule adopted by the Association in 1896 in regard to the minimum thickness of flange in locomotive truck wheels? (That they should be the same for both iron and steel wheels and 1 inch thick measured ¾ inch from top of flange.) (See page 327.)

A. 11 replies were made to this question, 10 of which were "Yes" and 1 "No."

Air brake and signal instructions.

Q. 62. Are you using the Air Brake and Signal Instruction Book adopted in 1898?

A. 19 replies were made to this question, of which 14 were "Yes" and 5 were "No."

Fusible plugs.

Q. 63. Do you agree that fusible plugs in locomotive boilers are not necessary, as agreed upon in 1899?

A. 23 replies were made to this question, of which 22 were "Yes" and 1 was "No."

Standard locomotive tests.

Q. 64. Do you follow the standards for locomotive tests approved by the Association in 1894?

A. 14 replies were made to this question, of which 3 were "Yes," 3 were "No," 7 were "In part only," and 1 said "he made no tests."

Shaking grates.

Q. 65. Do you use shaking grates for anthracite coal, as recommended in 1897, page 144?

A. 9 replies were made to this question, of which 8 were "Yes" and 1 replied "Partially."

Cylinder fastenings.

Q. 66. Do you use the form of fastening for locomotive cylinders recommended in 1898, pages 160-187?

A. 14 replies were made to this question, of which 6 were "Yes," 3 were "No," and 5 said "In part only."

Locomotive jacket iron.

Q. 67. Do you agree with the conclusions of the committee in 1897 that common sheet iron painted is a more economical locomotive jacket than planished iron?

A. 18 replies were made to this question, of which 16 were "Yes," 1 "No," and 1 was undecided.

Piecework.

Q. 68. Do you believe in piecework in locomotive repair shops, as recommended by committee in 1897?

A. 22 replies were made to this question, of which 18 were "Yes" and 4 were "No."

Air motors.

Q. 69. Do you agree with conclusions of committee in 1897 that air motors are of more general use around a shop than either steam or electric motors?

A. 22 replies were made to this question, of which 17 were "Yes," 2 were "No," and 3 replies say "It depends on circumstances."

Insulation.

Q. 70. Do you carry out recommendations of committee of 1898 about insulating cylinders, saddles and exposed parts of fire-box sheets?

A. 21 replies were made to this question, of which 16 were "Yes," 3 were "No," and 2 replied "Yes as to cylinders, but not as to fire boxes."

Feed-waters.

Q. 71. Are you following any of the suggestions of the 1899 committee on the best methods of preventing trouble from impurities in locomotive boiler feed-waters, e. g., by filtration or precipitation before it is put in the locomotive?

A. 20 replies were made to this question, of which 1 was "Yes" and 19 were "No."

Case-hardene iron.

Q. 72. As long ago as 1871 a committee reported that case-hardened iron was preferable to steel for working parts of locomotives; do you still agree with this conclusion?

A. 23 replies were made to this question, of which 13 were "Yes," 5 were "No," 4 say "Yes, except for bushings," and 1 says "In part only."

Tapered reamer.

Q. 73. Do you use the tapered reamer recommended as standard by Prof. Coleman Sellers in 1883? (See also page 28, 1890.)

A. 16 replies were made to this question, of which 12 were "Yes" and 4 were "No."

Use of pilot step.

Q. 74. In 1888 a resolution was passed that a step on the pilot was necessary for the convenience of brakemen making couplings; do you think this necessity still exists, even with M. C. B. pilot couplers?

A. 23 replies were made to this question, of which 10 were "Yes," 10 were "No," 2 say "It depends on the service," and 1 says "Not necessary, but desirable."

Hub liners.

Q. 75. Do you agree with conclusions of committee (pages 245-257, 1896), on the subject of HUB LINERS?

A. 23 replies were made to this question, of which 15 were "Yes," 4 were "No" and 4 say "In part only."

Cast-iron ring vs. brass ring

Q. 76. In discussion of report on steam pipe joints (in locomotive front ends) in 1896, cast-iron rings were said to be much preferable to brass rings; do you agree with this conclusion?

A. 22 replies were made to this question, of which 9 were "Yes," 11 were "No" and 2 were undecided.

Slide valves.

Q. 77. Do you follow recommended rule (page 184, report of 1896) for design of balanced slide valves?

A. 19 replies were made to this question, of which 9 were "Yes," 6 were "No" and 4 say "Yes, with certain modifications."

THE PRESIDENT: Gentlemen, what is your pleasure with the report?

MR. HENDERSON: In moving the acceptance of this report, I think we want to go a little further. The committee has done so much work in preparing the index which was sent out with the original notice and it has been of such great interest and value to all of us that I think we ought not only to accept this report, but the acceptance ought to carry with it the thanks of the Association to the committee for the very efficient and careful work done in connection with the preparation of the index, and I move that we couple the thanks of the Association in connection with the acceptance of the report. (Seconded.)

THE PRESIDENT: It is moved and seconded that this report be received and that the Association tender its thanks for the efficient work performed by the committee.

The motion was carried.

THE PRESIDENT: Gentlemen, the report is open for discussion.

MR. DELANO: Before discussion begins I want to call attention to the fact — I did not know it until I received the program at this meeting — that this committee, of which I have the honor to be chairman, is a standing committee. I can certainly speak for the chairman in saying that he would like to have the committee discharged, and I believe that there is no real occasion for its remaining as a standing committee. I do not believe that there is useful work for a committee of this kind to perform every year. I think perhaps once in four or five years a committee of this kind might be able to perform some service of value. Furthermore, the report of the committee on Subject No. 9, which has already been dealt with, provides for a committee to prepare an index, a very much more elaborate index, as I understand it, than that prepared by this committee, and I think for these reasons the further existence of the standing committee is quite unnecessary, and I ask that the committee be discharged.

THE PRESIDENT: Gentlemen, what is your pleasure on the recommendation of Mr. Delano?

MR. VAUCLAIN: I move that the committee be discharged. (Seconded.)

The motion was carried.

THE PRESIDENT: The report, gentlemen, is open for discussion. If there are any remarks we would be glad to hear them.

MR. VAUCLAIN: I move that the discussion close.

THE PRESIDENT: Gentlemen, if nobody desires to make any remarks on this subject, I think it would be well to take up some of the subjects assigned for tomorrow morning's discussion, as we will have a short day tomorrow in view of the fact that we are invited to the Schenectady Locomotive Works. If there are no objections, we will proceed with the next paper. However, we leave that for the Association to decide. What is your pleasure, gentlemen?

MR. GARSTANG: Mr. President, I have not a program and I would like to know if there was only one topical discussion for today's noon hour.

THE PRESIDENT: There were two for today, but Mr. Quereau was not present and the topic which he was expected to open, "The Best Method of Securing Eccentric Straps to the Rods," was passed. What is your pleasure, gentlemen?

MR. GIBBS: I move that we proceed to the discussion of the next topic. (Seconded.)

THE PRESIDENT: It is moved and seconded that we proceed to the discussion of the next report, which will be on the "Relative Merits of Cast-Iron and Steel-Tired Wheels." Carried.

MR. WAITT: In the absence of the Chairman I will read the report, which is very brief.

Mr. Waitt read the following report:

REPORT OF COMMITTEE ON THE RELATIVE MERITS OF CAST-IRON AND STEEL-TIRED WHEELS.

To the President and Members of the
American Railway Master Mechanics' Association:

The committee appointed to report on the Relative Merits of Cast-Iron and Steel-Tired Wheels beg leave to submit the following:

The only report giving data has been received from the Union Pacific R. R., in which they state that the average cost of mileage of 33-inch cast-iron freight car wheels is 8 cents per thousand miles; the average cost of steel-tired wheels is 45 cents per thousand miles.

Mr. G. W. Rhodes, of the Burlington & Missouri River R. R., advises that he is of the opinion that 33-inch cast-iron wheels made to the M. C. B.

standard test is a safer wheel than some of the steel-tired wheels on the market.

Under these circumstances, your committee is unable to add anything additional to the report printed in last year's Proceedings.

J. N. BARR, Chairman,
A. M. WAITT,
H. S. HAYWARD,
A. L. HUMPHREY,
JOHN HICKEY,
Committee.

BALTIMORE, MD., June 1, 1900.

On motion of Mr. Sinclair the report was received.

THE PRESIDENT: The question is now open for discussion.

MR. DELANO: I move that this committee be continued and asked to report next year. (Seconded.)

THE PRESIDENT: It has been moved and seconded that the committee be continued and asked to report next year. Are you ready for the question?

MR. WAITT: Mr. Chairman, committee reports of this kind can only be of value where the committee can get data from the members, and the success for two years in trying to get data has not been very encouraging. I think it would be wiser to let the matter rest for awhile. A year ago the committee did receive several replies to its inquiry. This year the number of replies got down to two, and I think if the committee is continued for another year, it will be a minus quantity.

The motion that the committee be continued and asked to report next year was put and carried.

THE PRESIDENT: Mr. Rhodes, do you desire to say anything on that subject?

MR. RHODES: Mr. Chairman, I might say a word, perhaps, as I observe that I am selected as one of the few members of this Association who replied to the circular, and also because this is my first attendance at the Master Mechanics' meeting. When I see this report printed here, it looks a little bold, and I am afraid that possibly some of the members may wonder why I should have so much confidence in cast-iron wheels. One of the dangers in cast-iron wheels is the application of the brake-shoes to the wheel and the heating up of the surface of the tread. This has, in the past, caused the plate to crack and the wheels to burst and disastrous results follow, and it has given the Master Car Builders' Association a good deal of concern; but of late they have adopted in their specifications a requirement which very materially, if not entirely, does away with the danger of breakages. I am not quite sure how the Master Mechanics' Association does about its recommended practices, but I sometimes think we, as a body, do not pay as much attention to the recommended practices of those actively engaged in searching and investigating as we might, but being familiar with cast-iron wheel specifications and having had experience with the product from such specifications, I have learned to have confidence in wheels made to the specifications. When the thermal test of the Master Car Builders' Association was first discussed, the manufacturers, in some cases, objected to the thermal test. A matter came to my attention which surprised me quite a little. Some of the foundries from which we bought wheels rather objected to the thermal test, and when we subjected their wheels to the thermal test we found that they would not meet that test, but when we got out in the Western country where wheels are operated in the mountain districts without having any thermal tests, or without any being required, we found that the foundrymen in these locations made wheels which stood the thermal test. The explanation was pretty reasonable and I think is interesting, because, after all, the specifications which we adopt and the work which we do, both in the Master Mechanics' and in the Master Car Builders' Associations, is largely following what we have been taught by practice. I do not think we very often get up specifications that we originate entirely ourselves. I think that some of the members get to analyzing what is actual practice and they explain actual practice and finally reduce it down to a specification and then we are able to get better results. We found in the West that the foundries produced wheels which did stand the thermal test. Upon asking why it was done the answer of the foundryman was: "In this country, where shoes are applied so much with air brakes we could not sell wheels if they did not stand the heating from the application of the shoes." And that showed that actual practice had made the foundries in the West produce wheels more susceptible of severe brake application than was found in the East. But now, since the more general introduction of air brakes, the air brakes are being used as generally on all the cars, even on our level prairie lines, as they are up in the mountain districts, our associations have emphasized this thermal test. Now what I would urge the members of the Master Mechanics' and the Master Car Builders' Associations is, with the introduction of these air brakes, to pay a great deal of attention to this thermal test. Do not ignore that feature of our specifications. We have been buying wheels on the Burlington system for the last two years under the thermal test and I have yet to find a cracked wheel, a broken cast-iron wheel, cast in the last two years, that has been bought by the Burlington road. It is largely on this account that I express my views in this way about the cast-iron wheel. We have more heavy grades out in the West. What I have more especial reference to is, that it is not so important on the grades because they have been attended to, but it is important on the level roads on account of the general way in which we are applying brakes on all the cars.

MR. HENDERSON: I would like to ask Mr. Rhodes a question. He said, if he is quoted correctly, that in his opinion cast-iron wheels properly made are safer than some of the steel-tired wheels. That implies that steel-tired wheels in some respects are not as safe as cast-iron wheels. I would like to ask what particular point he has in view? Is it the loosening of the tire of the wheels from the application of the brake, or what is the special difficulty he has in mind?

MR. RHODES: What I have reference to is that cast-iron wheels will crack in the plate and will break if they are not detected and removed. With some of the wheels with steel tires applied we have had the same thing occur. Spokes will crack, and if they are not detected and removed the wheels will break and the tire will crack and break. I expect we have all had more or less experience in that line and therefore I gave the opinion that I did.

THE PRESIDENT: Are there any other remarks on this subject? If not, we will proceed to the discussion of the next subject, which is: "Advantages of Ton-Mile Basis for Motive Power Statistics." Mr. Small is chairman of that committee.

MR. SMALL: Mr. President, I had expected that Mr. Quereau would have been here today and was going to suggest that he read this report for this reason: This committee, as the members understand, was continued from 1899. The report presented last year was prepared largely by the chairman. It was not concurred in by the other members of the committee. Mr. Quereau, having given this subject a great deal of thought and discussed it a great deal during the past few years, the chairman requested that he write the report this year, which was done, and I had hoped very much that he would have been here to read it and to be present at the discussion. I would suggest that if there is a probability of Mr. Quereau coming to the convention tomorrow that the subject be deferred until that time.

MR. DEEMS: I would say that he will not be here during the convention. At least I had a message from him to that effect the day before I came away from home.

THE PRESIDENT: That being the case, Mr. Small, we had better proceed with the report. I think you can handle it very nicely alone.

MR. SMALL: I would state further that in signing this report, or rather in authorizing my name to be signed to it, it was done with a certain protest; I really do not concur in all that the report covers. Mr. Marshall, the other member of the committee, also declined to sign it, for the reason that Mr. Quereau, in this report, includes all character of service: freight, passenger, work and switching. Personally I am in favor of covering only the freight service, from which we get, of course, the benefit of ton-mile statistics. Passenger service is somewhat beyond the control of operating officers, although it could be, perhaps, brought in under the ton-mile basis to some extent, but switch and work services seem to me entirely outside, and that no accurate or definite data could be obtained. With that understanding I will read the conclusions and recommendations.

Mr. Small read the conclusions and recommendations of the following report:

REPORT OF COMMITTEE ON TON-MILE BASIS FOR MOTIVE POWER STATISTICS.

To the President and Members of the
American Railway Master Mechanics' Association :

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luded.

In the report of this committee presented at the 1899 meeting of this Association, we argued at length and in detail that all the items involved in the Cost of Engine Service statement should be based on the ton-mileage produced. It is not our intention to present this matter at length in our present report, but wish to emphasize the conclusions reached in that report by an illustration taken from a performance sheet for January, 1900, in which is shown the records made on the mile and ton-mile bases.

	Moguls, Simple. 19 by 24.	Consolidations, Compound. 21 by 31 by 24.	Per cent in favor of Simple Engines.
Cost per *Mile.*	Cents.	Cents.	
Oil and waste	.24	.30	25
Fuel	14.81	15.84	7
Repairs and supplies	2.51	5.08	103
Wages	6.93	7.63	10
Total	24.49	28.83	18
			Per cent in favor of *Compound* (except * *).
Cost per *10,000 Ton-Miles.*			
Oil and waste	$ .04	$ .03	33
Fuel	2.44	1.77	38
Repairs and supplies	.41	.58	40 * *
Wages	1.14	.85	134
Total	$4.03	$3.23	25

We believe the showing in the above tables a sound argument in favor of the use of the ton-mile basis, and for all the items making up the cost of engine service. We believe it advantageous to also have a statement showing the cost of engine lubricating and illuminating oils on the engine-mile basis.

COMPARISON OF STATISTICS.

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In our previous report we also argued that greater economies will be secured by comparing the statistics for a given system or division with those made by the same line in previous years, rather than with those of other roads, because when the comparison is made with other roads the conditions, which very largely control results, are, almost as a matter of necessity, so different that a just comparison can not be made, while this is not true when the comparison is with previous records made on the same line. In this report it is our intention to only emphasize this point and refer to our previous report for the extended argument.

STATISTICS.

Replies to our circular letter were received from fourteen roads using the ton-mile basis for their motive-power statistics.

Tonnage included in statistics.

The operating departments of thirteen of these used the ton-mile basis for their statistics.

The ton-mileage is compiled from the conductors' reports, usually in the Car Accountant's office, though there are two roads on which the work is done in the office of the Superintendent of Motive Power, one where the Auditor is in charge of it, and one where it is worked up by the Store Department.

On five roads the net tonnage, or that in the cars, is kept separate from the gross, while on nine it is not so separated.

There are eight roads which do not include the tonnage of the engine in their ton-mileage and five which do; four do not include the way-car and nine do.

East and west bound ton-mileage is kept separately by eight roads and is not by six.

All the roads reporting use the ton-mile basis for freight service; nine for passenger and freight; and three for passenger, freight, work and switch engines.

None of the roads in their ton-mileage add a per cent to the weight of empty or partially loaded cars to account for the additional power required to haul a ton of these as compared with fully loaded cars, though a number of them add it to their tonnage ratings.

It is difficult to surely say from their answers whether any make a practice of determining the actual weights of their cars and their contents except from the way-bills and stenciled weights, but it is evident that a number weigh the loaded cars where practicable.

On eleven roads the statistics for the main line and branches are shown separately.

Of the nine roads which keep their passenger service statistics on the ton-mile basis, seven add nothing to the weight of the cars for passenger baggage, express or mail, while two do. One adds to the scale weight of their coaches, chair cars and sleepers, two tons; to that of their baggage and mail cars five tons for their contents. Another adds three tons to all their cars in passenger service.

WHAT SERVICE SHOULD BE INCLUDED?

Service included.

The chief reasons for adopting the ton-mile basis for railroad statistics, in place of the mile basis, are that the former is a more accurate measure of the work done, and encourages economy in operating. We can see no good reason why these qualities are not as desirable for passenger service as for freight, though it will be admitted that greater economies will result in freight service. It is urged by some that the speed and weight of trains in passenger service are not within the control of division officials, implying that there is little use in trying to improve the records for this service, therefore there is no use in using the ton-mile basis for these statistics. This reasoning applies with equal force to a large proportion of freight service, such as stock, fruit express and fast merchandise, but is not considered to have sufficient weight to prevent the use of the ton-mile basis. We know that some men are more economical than others in passenger service, as well as in freight, and believe the use of the ton-mile basis is better than the engine-mile basis with which to determine their relative merits, and so encourage better records. It also seems to us desirable that both passenger and freight service statistics be on the same basis. This is apparently the view of nine out of the fourteen roads reporting, or nearly sixty-five per cent. To the actual weight of cars in passenger service we would suggest the addition of five tons for mail, baggage and express cars in main line service, three tons for such cars in branch-line service, and of two tons for such cars as carry passengers, whether in branch or main line service. Passenger cars hauled deadhead in freight trains should have no such credit.

Engines in work train and switching service are credited with an arbitrary number of miles per hour. We see no reason why they should not be credited with an arbitrary ton-mileage instead, which would give the same basis for the statistics of all classes of engine service which we believe is important and desirable. Nearly twenty-two per cent of the roads reporting are of this opinion.

We would suggest that *work engines* be credited with the actual weight of their trains, to be determined on the same basis as for freight engines, and with ten miles per hour. If the weight of the train is 500 tons, and the engine is in service ten hours, the credit for the day's work would be 5,000 ton-miles.

A. & B. R. R.

PROPORTIONAL POWER OF LOCOMOTIVES.

CLASS	A'7'			A'8'			B.			C.			D.			E.			G.			H.			K.		
	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT	PER CENT	WITH CLASS	PER CENT
	45	A'8'	55																								
	55	B	45	60	B	40																					
	60	C	40	60	C	40	50	C	50																		
	35	D	65	40	D	60	30	D	70	30	D	70															
	50	E	50	50	E	50	45	E	55	40	E	60	65	E	35												
	40	G	60	45	G	55	35	G	65	35	G	65	55	G	45	40	G	60									
	45	H	55	45	H	55	40	H	60	35	H	65	60	H	40	45	H	55	50	H	50						
	45	K	55	45	K	55	40	K	60	35	K	65	60	K	40	45	K	55	50	K	50	50	K	50			
	25	L	75	30	L	70	20	L	80	20	L	80	40	L	60	25	L	75	35	L	65	30	L	70	30	L	70

For 18 by 24-inch *switch engines* carrying 145 pounds of steam pressure and having 50-inch driving wheels, we would suggest a credit of 200 tons and eight miles per hour. For a day of ten hours this would make a credit of 1,600 ton-miles. For other switch engines the tonnage should be proportional to their power as determined by the formula in the next paragraph.

The credit for *pusher* and *double-heading* engines should be made on the basis of the proportional power of the engines attached to the train. This is quite easily determined by means of a table which can be made in the drawing-room, from the formula $T = \frac{d^2\,p\,s}{D}$, in which T is the tractive power, d the diameter of the cylinder, p the boiler pressure, s the stroke, and D the outside diameter of the drivers; all the dimensions in inches and the pressure in pounds. A sample of such a table, in use on a western road, is given herewith, the percentages being even multiples of five for convenience in calculations.

Ton-mile basi the most accurate for all classes of service.

We would sum the argument for the use of the ton-mile basis for all classes of engine service as follows : It is the most accurate practicable basis for measuring the work done in freight and passenger service; an arbitrary ton-mileage credit for switch engines is as accurate as an arbitrary mileage credit and has no disadvantages; for work engines a credit for the actual tonnage handled and an arbitrary mileage per hour is more accurate than a credit of an arbitrary mileage only; it is desirable to have the same basis for all the classes of engine service.

WHAT TONNAGE SHOULD BE INCLUDED.

Difference between ton-mileage and tonnage rating.

There are evidently differences of opinion as to what tonnage should be included in making statistics. Some are decidedly of the opinion that the entire weight of the train, including the engine, tender and way-car, should be used. Others contend, with equal conviction, that only the weight of the cars and their contents, excluding the way-car, should be used. It is quite possible that this difference of opinion may in some cases be due to a confusion of the terms "ton-mileage" and "tonnage rating." The ton-mileage of a locomotive for a given trip is ascertained by multiplying the weight of its train, reduced to tons, by the number of miles this tonnage is hauled. The tonnage rating of the same engine is quite a different matter, being simply the number of tons it is rated to handle, and does not necessarily have any relation to its ton-mileage. As the weight of a given engine and its way-car is always the same, there is no good reason why the tonnage rating should include these weights, as the object of the tonnage rating is simply to always secure a weight of train which shall be the greatest practicable under service conditions.

It may seem that this line of reasoning should be applied to the ton-mileage, and that, because there is nothing gained by including the tonnage of the engine and caboose in the tonnage rating, therefore it should not be included in the ton-mileage. It seems to your committee that this does not logically follow, because the objects of the tonnage rating and that of the ton-mile basis for statistics are entirely distinct. The tonnage rating is used as a measure of the capacity of the locomotive, while the ton-mileage is intended to show the work actually done, regardless of whether the tonnage rating is handled or not, as a basis for the cost of engine service.

One of the favorite arguments of those who favor the exclusion of the ton-mileage of the engine and way-car is that the management wants to know what their engines are hauling behind the tender. Admitting, for the sake of argument, that this position is correct, no better statement could be made to show that the weight of the way-car should be included in the ton-mileage.

Motive-power ton-mileage statistics should represent tota work done for money spent.

It is argued that there are engines of modern design which will haul more tons of freight behind the tender for each ton weight of engine than others, which are not so well designed, and therefore the weight of the engine and tender should not be included in the ton-mileage, so as to make a better showing for the modern design. We question the relative importance of this information, believing that the cases where it would apply are comparatively limited, and that the desired information could be obtained more accurately either by calculation or special tests. In short, that it is more important that the motive-power statistics be based on a ton-mileage which will represent as nearly as practicable the total work returned for the money spent than to leave out of the account a considerable percentage of the work done for the sake of exceptional conditions.

It is claimed by some that the weight of engine and tender should be omitted on the same basis that the owner of a stationary engine wishes to know the power delivered by the fly-wheel rather than the total power developed in the cylinder. The cases are quite different. The power absorbed by the stationary engine is simply that necessary to overcome the internal friction, amounting possibly to eight per cent of the total developed, and it does not run without a load. With a locomotive, in addition to the internal friction, there is the power absorbed in moving its own weight, which frequently, even with its maximum load, amounts to thirty-five per cent of the total power developed. In rating and judging the efficiency of a stationary engine both its owner and builder include in the work performed that absorbed by the shafting which it drives, amounting frequently to fifty per cent of the total power developed, and frequently that absorbed by internal friction. It would seem that those who advocate the omission of the ton-mileage of the locomotive and its tender can find scant grounds for their position from stationary practice.

We believe that the motive-power department, rather than the management, has been responsible for the use of the engine-mile as the basis for their statistics, and has generally taken the initiative in urging and adopting the ton-mile basis for their department. In short, that, as a rule, the manager has been so fully occupied with other matters that he has not given the necessary time to a careful study as to what basis for motive-power statistics is the best, or its influence, but that the use of a given basis has been sanctioned as the result of the representations of motive-power officials. Whether this conclusion is warranted by the facts or not, it seems to us that the motive-power official should first consider the needs of his department and venture to give the manager the reasons for his conclusions. If, with a few changes and at a comparatively small additional expense, the motive-power ton-mileage can be made to serve the management in more accurately determining the cost of transportation, it seems as though this should be for the management to determine, but that as motive-power officials we should recommend what, in our judgment, is the best plan for the use of our department in determining the cost of such items as we are responsible for. It will be admitted without argument that the management is interested in knowing the cost of motive-power management, but we believe they are specially interested in the broader field of operating cost, and that we will fall short of our duty if we do not fully represent the matter from our standpoint, and can not fairly be considered as going outside our province if we venture to assume that, from the nature of the case, we should know our needs better than those who have not specially studied them. If this statement is reasonable, it follows that the interests of all concerned would be best served by a joint committee representing the operating and motive power departments, which should consider the subject for both.

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ould include
ight of
ire train.

Viewing the matter from a strictly motive-power standpoint, we are of the opinion that the ton-mileage should include the entire train — the engine, the cars with their contents, and the way-car. The strongest argument in favor of this view is that the best basis for determining motive-power costs is that which includes all the work produced by the money spent. The management is specially interested in knowing the cost of hauling a ton of paying freight one mile. This would exclude from the ton-mileage that of the engine, the light weight of the cars, including the way-car, and of company material. It is exceedingly doubtful if any motive-power official will claim this is a proper basis from which to find out whether his department is being managed economically or not, simply because it evidently would not furnish an accurate measure of the work done by the money spent. As it would give no credit for work done in hauling empty cars, company material, for an engine and way-car, or for a light engine, we would justly argue that statistics on such a basis could not fairly be used to measure our efficiency as motive-power officials, and would be of little practical use in helping us to reduce costs intelligently. Empty cars and company material must be hauled; locomotives with only a caboose, and without a caboose, must run over the road; this work necessitates an expenditure of money by the motive-power department and is in no way under its control. Is it not reasonable to claim that there should be a credit for this unproductive work against which to charge the money spent in doing it?

Motive-power and operating departments each to have proper basis for statistics.

Under the head of "Statistics" it is worth noting that, of the fourteen roads reporting, on all but one the operating department uses the ton-mile basis for their statistics. The needs of the operating and motive-power departments in this matter are quite different. The operating department wishes to know the per cent of empty to loaded ton-mileage, the per cent of actual to rated ton-mileage, the average tonnage of load per car, so that the per cent of useful work may be increased. On the other hand, these matters are of minor interest to the motive-power official, and then only as they affect the efficiency of his department. The motive-power officer is interested in knowing the actual work performed, not with a view of bettering the efficiency of the operating department, but his own.

If our statement of the case is correct, it follows that there are three interests to be served by ton-mileage statistics: Those of the management, which wishes to know the cost of handling a ton of freight one mile; those of the motive-power department, which we believe is entitled to a credit for all the work performed by the money it is responsible for; and those of the operating department, which finds the ton-mile basis the best practical one for reducing the per cent of unproductive work in handling their trains. If this is a fair statement of the case, it follows that the needs of no two of the departments are the same, and therefore a compromise will serve the best interests of neither. It will be admitted that the management is interested in the statistics of both the other departments, but we venture to assume we are warranted in believing that it is to the best interests of the management to allow each such a basis for their statistics as will favor its greatest efficiency.

There is an opinion, judging by editorial comments and personal remarks, that the expense for the three statements which we advocate will be prohibitory. We believe that a study of the facts will show that such is not the case. For the motive-power ton-mileage the addition of that for the engine and way-car will cost practically nothing, as will be readily understood when attention is called to the fact that these are constants for any given district and will not have to be figured out for each trip. For instance: A 15-ton caboose going over a 120-mile district will have a ton-mile credit of 1,800 for each trip; a 200-ton engine on the same district will have a credit of 24,000 ton-miles for each trip; and on each district there will be such a constant. The additional expense for adding these constants to the footing of the ton-mileage for the operating department, which should not include them, will be scarcely appreciable. On one road the ton-mileage of the engine is added in the office of the Superintendent of Motive Power, where the weight of each engine and its mileage are known.

It is probable that the ton-mileage statistics of the operating department should show separately that for the lading, for the loaded cars, for the empties, and east and west bound traffic in order to be of the greatest usefulness. If this is correct, it follows that the additional expense for furnishing the ton-mileage for the management, which should show only that for the contents of the cars, would be only that necessary to draw off these figures as a separate statement from among the totals needed by the operating department. It would therefore appear that the expense for ton-mileage figures for each department, best suited to its uses, would be but very little greater than for a compromise statement which would serve the best interests of neither.

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istics.

The preceding argument has referred only to the expense for compiling the ton-mileage. We believe it safe to assume that the expense for figuring out the statistics based on ton-mileage will, after the first year, be no greater than it has been for furnishing the corresponding statistics on the mile basis. This has been the experience of others and seems a reasonable proposition. If the ton-mile statistics are more elaborate, it will follow that the expense will be somewhat increased. In this connection it is worth noting that for the first year the ton-mile statistics are used; it will be necessary to keep those based on the mile, if a comparison of one year with another is desired.

CONCLUSIONS AND RECOMMENDATIONS.

clusions.

The ton-mileage for the use of the motive-power department should include the weight of the entire train.

For the use of the operating department it is probable that all that is needed is the weight between the tender and way-car.

The best interests of both departments will be best served by a joint committee representing both.

FOR THE MOTIVE-POWER DEPARTMENT.

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s.

We recommend that all the items making up the cost of engine service be on the ton-mile basis;

That the statistics of all classes of engine service be on the same basis;

That in passenger service five tons for mail, baggage and express cars in main-line service, three tons for such cars in branch-line service, and two tons for all cars carrying passengers, be added to their scale weights; passenger cars handled dead-head in freight service should have nothing added to their scale weight;

That engines in work train service be credited with the actual weight of the entire train, to be determined on the same basis as for freight engines, and with ten miles per hour;

That switch engines having 18 by 24-inch cylinders, carrying 145 pounds steam pressure and having driving wheels fifty inches outside the tire, be credited with 200 tons and eight miles per hour; for others the tonnage should be in proportion to their power, compared with that of the standard, and eight miles per hour;

That for pusher and double-heading service the credit for each engine attached to the train be its proportion of the ton-mileage, based on its power, for the distance covered by each;

That it is desirable to group the individual fuel statement and oil statement, each service by itself;

That the statistics for main line and branches be separate;

That the weight of the contents of freight cars handling way freight should be that with which it left the terminus;

That the ton-mileage of mixed trains, where both freight and passengers are handled in the same train, should be credited to that service which is entitled to the greatest per cent of it;

That the tonnage of a locomotive should be its weight in working order plus that of the tender with half its capacity of coal and water.

H. J. SMALL, Chairman,
C. H. QUEREAU,
Committee.

SACRAMENTO, CAL., May 20, 1900.

NOTE.—*Mr. W. H. Marshall, the third member of this committee, advises that he can not agree with some of the recommendations, and therefore declines to sign the report.*— SECRETARY.

On motion of Mr. Sinclair the report was received.

THE PRESIDENT: The report is received and is open for discussion.

MR. HENDERSON: Mr. President, I suppose we all have our own peculiar notions about the special methods of rating engines, not only of rating them but of charging up the supplies on the ton-mile basis, and I notice that the committee itself has not been without certain dissensions. I for one do not agree entirely with the method proposed of including the weight of the engine and tender in the work done per ton-mile per pound of fuel or per pint of oil, and I think that we ought to really consider the work actually done back of the tender as the unit to be adopted. Of course I know the report states the ground which I was going to make and disclaims the advantage of it; in other words that because a certain engine of better design is somewhat lighter and is enabled to haul more load behind the tender instead of its own load, the report disclaims that there should be any credit allowed to the engine on that account. I differ from that. I believe if we can produce an engine with the same tractive power and of lighter weight so that the weight of the engine is taken in part by the weight of the train, that that engine is certainly entitled to the benefit of the extra ton-mileage that it would haul; whereas, if we included the extra weight of engine and tender, there would be no extra credit for that design. I think it would be more accurate and more desirable to take the data on the basis back of the tender than to include the weight of the engine and the tender itself.

MR. W. H. MARSHALL: As a member of the committee, I did not feel that I could sign this report. I regret being in this position, because I believe thoroughly in the ton-mileage system; but it seems to me that, while there are good features in this report, it goes altogether too far. In the conclusions and recommendations of the committee we are asked to include in the ton-mileage to be used by the motive-power department the entire weight of the train. It seems to me that the members of this Association have a dual task. They may be, and ought to be, interested in the performance of locomotives from a scientific or expert view; but there is another side of it which compels them to look upon locomotive performance in exactly the same light that the management does, which is that, irrespective of design or anything else, the essential thing for the railroad company is what an engine does behind the tender. In the body of the report the argument is made that the engine should be credited with all the work it does, and that, furthermore, the work behind the tender is not of any particular advantage to anybody, because the transportation department, instead of using those figures, must consider the net revenue load. I do not look upon it in that light. It seems to me that the load behind the tender is one of the most important considerations for both departments. The great essential, one might say, is to see that the engines haul what they are capable of hauling. The next thing is for the transportation or other departments to see that as large a percentage as is practicable of the tonnage behind the tender is paying freight. We who are interested in the car work are interested in that subject also, as it involves car construction as well as the proper loading of the cars. I believe statistics that are made by the motive-power department should as far as practicable be directly applicable to the work of other departments; in other words, that we should not have ton-mileage figures and engine-mileage and car-mileage figures that will not agree with the same figures used in other departments.

I judge from this report that it is the intention to put all the items that are involved in the cost of engine service, for all classes of service, on a ton-mile basis, and a ton-mile basis only. I think if we abandon the engine-mile basis entirely we lose a very valuable comparison for certain items. Take, for instance, roundhouse labor; suppose large engines are put on a certain division; certainly, as far as the hostling is concerned it does not require very much more to hostle a large engine than a small one. You can readily see that this and some other items can be analyzed quite intelligently from the engine-mile basis. If we put the accounts on a ton-mile basis entirely, some of the items would show an immense reduction per thousand ton-miles, and we would have no reason to take any credit to ourselves for it. I believe, on the whole, as long as we have to furnish figures on the engine-mile basis to the auditing and other departments, we should continue the engine-mile basis to supplement ton-mileage figures, making the ton-mileage figures, in freight service particularly, the more important and the figures by which we will judge of our performance, and use the figures on the engine-mile basis simply as an interpretation or a side light on the others.

It is recommended that engines in work-train service be credited with the actual weight of the entire train, to be determined on the same basis as for freight engines and with ten miles per hour. It is practically impossible to obtain the actual tonnage in work-train service and it is comparatively easy to obtain the actual mileage. We are asked to use tonnage figures that we cannot get and to abandon mileage figures that we can get, and use an arbitrary mileage per hour instead. I do not think, in view of the irregularity of work-train service anyway, that it is necessary to do this.

The recommendation for switch engines is that we shall use an arbitrary ton-mileage. The engine-mileage is arbitrary now. We have to keep it and have to report it. I do not see why we should adopt a second arbitrary quantity. It has occurred to me that if we want to put switch-engine performance on any ton-mile basis, we might hold to the engine-mile basis and make a supplementary set of figures showing the cost of switch service by divisions on the basis of the thousands of ton-miles (road service) handled over that division, but I do not see that those figures would be of very much practical value.

It is also recommended that statistics for main lines and branches be separate. I believe that that is a matter which ought not to be recommended, for the reason that conditions vary, so that the recommendation might not be of very much value in some instances. I know of one recent case on a large road where there was an enormous difference between the amount and character of work on the branches and on the main line, and it was thought that by separating some of these figures the real improvement in average trainloads on the main lines might be more clearly established; in other words, that with many small branches, the operating and other departments were handicapped in making a showing on the average revenue train, because a big improvement on the main line made a very small percentage on the whole. When the figures were analyzed it did not show up that way at all. On the main lines a good deal of the service was fast and there was considerable light car mileage that cut down the average weight of trains. On the other hand, on some of the small branches that only had one or two trains a day, these trains picked up everything on the division and brought it in, and their average train was nearly as large as that of any on the main line.

Mr. Gillis: It has occurred to me that in addition to computing the cost on the basis of the ton-mile, including the dead weight of the cars, which is the best comparison, it would be very valuable information to judge of the performance of the engines if the motive-power department would compute the cost per ton-mile of paying freight, not including the dead weight of the cars or engines. This cost per ton-mile of paying freight is, I believe, the best basis for comparing the economy of the motive power department.

Mr. Delano: I think our members must have noticed that the more knotty and difficult a question is the harder it is to get any action that suits everybody. We have on this committee some of the most devoted and hard-working members of the organization, and while apparently a small amount of progress has been made, at the same time I want to encourage that committee to go on, and I would like to see it continued. To give some idea of the amount of importance in which this subject is really held, I will state that the American Railway Association has quite a large committee appointed to look into the matter. The Railway Accounting Officers' Association appointed a committee a year or two ago and made some recommendations. Some of the technical papers have looked into the matter, and what all these committees and all those who investigate the subject run up against is that there is a very great difference in the methods of keeping statistics, and even if I say it myself I think it is true that a great many motive-power officers do not know in the minute details just the basis on which their own figures are made up. The making up of figures has gotten into such a shape that in some cases it is left to some patient, painstaking, plodding clerk in the auditor's office or in the motive-power office who has been grinding out figures month after month, and when you get right down to how the details of those figures are made up I venture to say that any motive-power officer will be surprised by what he finds.

I agree with what Mr. Henderson and Mr. Marshall have said in regard to not including the engine as part of the tonnage of the train; but that does not begin to be the only difference in the basis on which motive-power statistics are made. The train-mile does not mean the same on all roads; the engine-mile does not mean the same, and I venture to say that the ton-mile does not mean the same. On some roads they have found the necessity of adding an arbitrary tonnage for empty and partly empty cars, and that is done for rating purposes, but it is very easy to confuse that idea with the tonnage rating for statistical purposes. We begin by saying that for an empty train we will add an arbitrary tonnage, say, of seven tons per car, so as to make it on a par with the tonnage of a loaded train. From that small beginning there creeps into our figures some tonnage statistics that are purely wind. This subject was discussed at the Western Railway Club and gone into quite a little by that club, and I hope very much that this committee will be continued and patiently dig into the matter further and not feel discouraged because they have not made more progress. It is a knotty problem.

MR. RHODES: The chairman of this committee not being present and the few who have spoken on the subject having taken rather opposite views from his, I feel like saying something which I believe he would say if he were here. The object of these statistics is, of course, to obtain better results. We found that with the increase in carloads and car weights the unit of a car was no longer reliable, and that when we came to measure up the performances of the men who operate the engines by this car unit that we could not measure them up fairly and I think that that is a side of the question that we do not want to lose sight of. I believe that a great deal of economy can be produced by getting the coöperation of the men operating the head end of the train, and to get their coöperation you have to show them figures and results, and to entirely secure them with you, you have to show that your figures are fair; that is to say, that you are measuring these men properly. I believe if you leave out a portion of the tonnage that helps to consume the coal and the other material used on an engine, you are not going to be able to put yourself in a position to say that you are entirely fair in the method of measuring. What I mean by that is, suppose I am an engineer, and I am hauling 700 or 800 tons over a division and business is light one way and I have to run light, and I get instructions to go two hundred miles west with a way-car and I burn the coal all the way going those two hundred miles and it is not measured up in my performance. Afterward, at the end of the run — I may have had to do that frequently during the month — my record may show very badly compared with those who have not had to haul that light train one way — that is to say, the engine and the car to which no tonnage is allowed — but I have had to haul the heavy train backward. I think it would be a little discouraging, a little disheartening, if I was told that was not considered, was not accounted for. In some places on many lines, at the end of the terminal, they have to deliver certain cars to certain places away from the terminal. We do on our line. At the end of the terminal when we have delivered our train of thirty or forty cars, there is one point where we frequently have to take a way-car and two cars and go four or five miles. If you only get the tonnage for the two cars and no tonnage for the engine and the way-car, the measure is not very equitable. I believe the chairman of this committee would say that if he wants the coöperation of the enginemen who are operating the engine that it is going to be very essential that everything that tends to consume the fuel and the supplies on the engine be taken into consideration.

MR. MARSHALL: I am very glad that Mr. Rhodes has stated what he has, because I feel reluctant to object to so many points in the report, with Mr. Quereau absent. I would like to say one thing, however, about this matter of comparison of performance among the men. I will grant that there may be some conditions where that would be important, but on the average I do not think it would. I have taken the figures on a ton-mile basis and analyzed them to determine the effect of putting the weight of the engine in the ton-mile figures for this reason: If you will take the coal consumption on a ton-mile basis by different engineers and separate them into groups that are as nearly comparative as you can make them, you will probably find in freight service that you have results something like this: Here are, say, a dozen men in a pool on a certain division, and they are listed in the order of their economy in coal consumption. If you look at the column for the average tonnage of the trains you will find (if the men are about equally good) that the man who is most economical probably has a 900-ton train for the average of the entire month, including all his light engine-mileage, etc., whereas the one who is most expensive has had 350 or 400 tons; in other words, the figures in the column showing the economy of fuel and in the one showing the average tonnage in the train are in inverse order; one grows large as the other grows small. I thought to analyze those figures and see to how much it amounted to put the weight of the engine into those ton-mile figures; it did not make one per cent difference. They stood in practically the same order as before. When you come to think it over I think you will see the reason is that the man who has a very light train on an average for a month has been compelled to make higher average speed; that is where the coal has gone.

As I understand it, the statistics we are considering are not those we might use in comparing the individual performance of the men or in posting information to show what they have been doing, but they are the general statistics of the department.

MR. SMALL: I would like to state on behalf of the committee that its report of 1899 should be considered in connection with this report. The report of 1899 gave, I think, some definite recommendations and I think perhaps a certain form for reporting statistics. The committee of 1899, in its investigation, showed conclusively that the advantages of the ton-mile statistics were recognized by the great majority of the members, and I think the convention of the Association adopted that idea at the time. The committee was continued, I suppose, with the view of presenting further information, and it has done so, rather more to bring out discussion from the Association. The result of the committee's work this year would·indicate that it would be very difficult to bring all the roads to adopting one system of statistics. I do not know what the committee could do another year further than to present another report on different lines and keep on doing so until it strikes something that would meet the approval of the convention.

THE PRESIDENT: Are there any other remarks to be made on this subject? It seems to me this is one of the most important subjects before this Association and there are a great many members present who have had a good deal of experience in this matter. I believe it would be a good thing if we could hear from them.

MR. McINTOSH: It occurs to me that the weight of the engine would not cut much of a figure in its influence on the men, but if it was necessary to make up separate reports to furnish that information it would be quite expensive, and the nearer the report can be placed on a commercial basis or the basis on which general reports are made up, it would be better.

MR. A. E. MILLER: Mr. President, the question has been touched on by Mr. Rhodes and Mr. Marshall, of that which would give to the engineer, or rather to the engine crew, definite information as to what they are doing compared with other men. If that matter is to be considered there should be something in connection with the report on the ton-mile basis that would show the conditions of service under which the work is done. Take for instance the varied service on our road — and I presume that service is the same on other roads to a greater or less degree — one crew will take a full train and go over the road; possibly the crew following him will take what is known on our road as a pick-up train. We have a number of interchange points where cars are set off and others are taken on and the train tonnage is maintained, but in the maintaining of that train tonnage the hours of service of the engine are increased and the switching service is increased. One crew may catch just such a train as that eight or ten times a month; another crew may not happen to catch a train of that kind at all. The men know these conditions, and these statements are important for the crews that are interested in making an effort to do as much or more work than others with the least cost for supplies, and in order to encourage them in their work and make an intelligent report to them, there should be something in connection with the ton-mile basis that would show the difference in service between getting over the road in eight or ten hours and twelve or fifteen hours.

MR. J. F. DEEMS: In connection with ton-miles and ton-mile basis, especially when used for such reports as have been referred to by the gentleman speaking last, that is, reports for the benefit of the enginemen, I have had to do with such reports for quite a good many years, and I fully agree with what Mr. Henderson and others have said as to the very small effect that the weight of the engine would have, owing to the fact that there are so many other elements of uncertainty entering into the question — that is, the question of one man getting trains perhaps west-bound and up grade, and another possibly during the month gets most of his trains in the opposite direction. The question of loaded or partially loaded cars is referred to here, but it is a very difficult one to handle, and the question of switching and all those things enter into it. One might infer from what has been said by some of the other members, and it might be inferred from what I am saying, that we think those reports do not amount to anything. I believe that is wrong. While it is a fact that they may not be strictly accurate, I think they do a great deal of good, but I think the great advantage in a report of that kind is to get it out promptly. I would much rather have a report within six or eight days after the close of the month that was a little crude than to have a very elaborate one about thirty days later. It would do more good with the enginemen. They like to see it that way very much better. It strikes me if we undertake to bring into that report all of the elements necessary to make it strictly correct, it is going to get out so late that it will not be of much value. That has been my experience, at least, in handling ton-mile figures in connection with oil and coal records, etc. I believe that is something that is well worth the consideration of the committee.

Mr. Pomeroy: I believe there are a great many recommendations and points made in these reports which a large number, yes, a majority, of the members would heartily agree to. Would it not help to clear the way for any subsequent work to put in the form of a resolution the sense of the meeting on the points that they could agree upon, thereby narrowing the discussion to the debatable points only? For example, the first item in the conclusions and recommendations, "The ton mileage for the use of the motive-power department should include weight of the entire train"; a vote on that subject might probably show where the majority of people stand on that question and dispose of at least this much of the subject.

Mr. G. W. West: I would like to say just a word or two in connection with this matter. We have recently added a very heavy locomotive to our equipment. In making reports to our General Manager as to the performance from day to day, on successive days the engine was reported as hauling thirty-five cars one day and thirty-four the next. He immediately called my attention to the matter, and in looking for an explanation I happened to meet the engineer who had the train of thirty-four cars, and he said to me: "The day I had that train they were all air-brake cars, and the day the other fellow had it he had a train of thirty-five cars with no air-brakes on." It ran along a few days and the same report came in, and in that case we figured the tonnage, and the engine had thirteen tons more in the thirty-four cars than she had in the thirty-five. In a paper read before the Central Railway Club, at Buffalo, by Professor Breckenridge, of the University of Illinois, two months ago, that thing was very forcibly illustrated, that an engine will haul a thousand tons in twenty-three cars a great deal faster and at less expense than in thirty cars. It seems to me, while we are quibbling over the weight of the engine there are many other conditions connected with train service that would more than offset the difference between different designs of locomotives.

Mr. Henderson: Mr. President, I move that the committee be continued and the discussion closed.

The motion was seconded by Mr. Delano and carried.

The President: The next question on the program is the question of flanged tires. Mr. Higgins, I believe, is the chairman of that committee.

Mr. Lewis: I move we adjourn.

Mr. Vauclain: Before that motion is placed, I move that the noon hour tomorrow be changed from 12 o'clock to 11 o'clock. If the members are going to Schenectady at 1 o'clock there will be no opportunity after 12 o'clock for a noon-hour discussion, and if I am to participate in that, the hour will have to be changed to 11 o'clock, because I propose to go home tomorrow evening.

Mr. West: Before that motion is put, I think I heard Mr. Higgins say that he is obliged to leave tonight, so if that paper is put off until tomorrow we will not have the benefit of Mr. Higgins' experience.

Mr. Lewis: I will withdraw my motion. I did not know that Mr. Higgins was here.

The President: The question is on Mr. Vauclain's motion that the topical discussion tomorrow take place at 11 o'clock instead of 12 o'clock.

The motion was carried.

The President: We will now hear from Mr. Higgins.

Mr. Higgins: Mr. President, I would like very much if this report of the Committee on Flanged Tires could be postponed until tomorrow. I left home very hurriedly and it is over a month since the report left my hands, and I would like to go over it again and freshen up on it a little bit. Furthermore, I would like to confer with the other members of the committee this afternoon. We made an appointment for this afternoon expecting that this report would come up tomorrow. I would like very much to have it go over until tomorrow.

Mr. Lewis: I move that we adjourn.

The motion was carried and the convention adjourned until the following day.

SECOND DAY'S PROCEEDINGS.

The convention was called to order on Friday, June 22, at 9:10 A.M.

THE PRESIDENT: Gentlemen, I will now declare the convention open for business. The first order of business this morning is the reading of the report on flanged tires.

MR. S. HIGGINS: Mr. President, the report of the Committee on Flanged Tires, which is submitted to this convention, should be taken as supplementing the report of one year ago, which report was not entirely satisfactory on account of the difficulty we had in reading the dynamometer which we used at that time. This report is not very long and the principal thing that I desire to call attention to is the fact that this year we had the benefit of a dynamometer car that was furnished by the Erie Railroad, and that car was in charge of a young man who has been with it for some time and is very familiar with its workings. The committee, as a result of the tests that were made on the Lehigh Valley Road, near Wilkesbarre, is unanimous in thinking that we are justified in using flanged tires on all the driving wheels of a mogul ten-wheeler or a consolidation engine. As shown on the diagrams, the tests were made on the same piece of track we used one year ago, and this year we tested the ten-wheel engine as well as the consolidation, whereas a year ago we confined our work to the consolidation engine alone. There are a number of diagrams that should be carefully considered, which diagrams show the results of the tests. I do not think there is anything more I can say in regard to the matter.

THE PRESIDENT: Mr. Higgins, I would suggest that you read the last three paragraphs of your report, on page 4.

Mr. Higgins read the last three paragraphs on page 4 of the report. The entire report is as follows:

REPORT OF COMMITTEE ON FLANGED TIRES.

"Is it desirable to have flanged tires on all the drivers of mogul, ten-wheel and consolidation engines? If so, with what clearance should they be set?"

To the President and Members of the
American Railway Master Mechanics' Association:

The original report presented one year ago contains the results obtained at that time, which results the committee did not consider to be conclusive on account of the difficulty experienced in taking the readings of the dynamometer that was placed between the engine being tested and the engine doing the work. The results now presented, in the opinion of the committee, can be taken as conclusive and reliable in every respect, inasmuch as they were obtained with a self-registering dynamometer car of approved construction, the operation of which will be explained further on in the report.

For information concerning present practice as to tire arrangement on mogul, ten-wheel and consolidation engines the members of the Association are referred to the first report.

Conditions of tests.

The committee met in Buffalo, N. Y., last fall, and the meeting was attended not only by the members of the committee, but also by representatives of the Roadway Department. At that meeting it was decided to do the work with a self-registering dynamometer car, the tests to be made on the line of the Lehigh Valley Road at the same place where the tests were made one year ago. The tests to include not only a consolidation engine, but also an engine of the ten-wheel type. It was furthermore decided that the track on which the tests were to be made should be put in first-class shape with elevation and gauge on curve to represent what is the average practice at the present time. It was decided that a test should be made with ten-wheel type of engine, and with each tire arrangement, on straight track to ascertain the lateral motion of the engine. It was agreed that both engines to be tested should be engines just out of the shop with the lateral motion between hub of wheel and box $\frac{1}{16}$ inch on each side.

Immediately after the meeting of the committee at Buffalo last fall a circular was sent out to obtain the practice on railroads in regard to elevation and gauge on curves. Before the last series of tests were made all of the conditions as enumerated in the foregoing were complied with. The diagram on Plate I (Appendix), accurately represents the track on which tests were made, the track used being the right-hand or east-bound track, and the flags shown on diagram represent the points between which the readings were taken.

The lateral motion of the ten-wheel engine on straight track with each tire arrangement was determined with an instrument known as a hydrokinetimeter; the drawing of this instrument is shown on Plate II (Appendix). As before stated, dynamometer tests were made with a consolidation engine, also with an engine of the ten-wheel type. The spacing of the wheels, weight on each pair of wheels, etc., are shown on Plates III and IV.

With both engines main rods and valve rods were disconnected, boiler and tender cisterns were full of water, and there was about two tons of coal on each tender.

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The dynamometer tests were made by hauling the engine to be tested through the curve, entering at the lower end so as to have the grade (56 feet to the mile) to contend with, at speeds approximating ten, twenty and thirty miles per hour for each engine, with each tire arrangement. The start was made at a sufficient distance from the first flag, to enable the engineer to get the test train at the desired speed when passing that flag. The test trains were made up in the following order: First, Engine hauling train; Second, Dynamometer car; Third, Engine being tested. The couplings were blocked with wooden wedges, to take up the slack.

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The hydrokinetic tests were made between two semaphores, 2.63 miles apart, on straight and level track. In making the tests the train was started at the first semaphore, and brought to a speed approximating forty miles per hour, which was maintained until the second semaphore was passed, when the train was gradually brought to a stop.

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Three series of dynamometer tests were made with each engine, or six in all. The first test was made on the morning of April 10, and the tests were finished on April 12. The distance between backs of flanges on engine truck wheels in all tests was 53¼ inches. The distance between backs of flanges on driving wheels, in all tests except No. 6, was 53¼ inches. In test No. 6 the distance between backs of flanges on front and back pair of drivers was 53⅛ inches, while this distance for the middle drivers was 53¼ inches.

The plain tires were located on driving-wheel centers so that the center of the tread of tire coincided with the center of the rail head on straight track. Tires used were Master Mechanics' standard section, flanged tires 5¾ inches wide, plain tires 6½ inches wide.

The records obtained in the dynamometer test are shown on Plates 5 to 22, inclusive. A summary of these tests is shown on Plate 23. A comparison of results of the tests on engine No. 710 is shown on Plate 24, and on engine No. 689 on Plate 25. The results obtained from engine No. 710 by the hydrokinetic tests are shown on Plate 26.

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namometer.

For the better interpretation of the dynamometer records, a brief description of the apparatus is given below. The drawbar at one end of the car is connected by an adjustable yoke to a pair of twin springs, all lost motion being removed by the adjustment of the yoke. Any movement of the drawbar, relative to the car, is transmitted to a sliding crosshead on the recording table. The motion of the drawbar, in being transferred to the recording table, is doubled by a lever having arms at the ratio of 2 to 1. The springs having been accurately calibrated, a curve of the springs is platted, as shown on Plate XXVII, doubling each ordinate, so that the record of drawbar movement, by reference to the curve, can be translated directly into pounds pull. A sheet of paper is moved across the record table, by means of gearing driven from the truck axle. The two sets of gear, either of which may be thrown in or out by a lever under the record table, give movements of 12 and 24 inches of paper, respectively, to the mile. In the tests under consideration, the paper had a movement of 24 inches to the mile. The crosshead on the table, which is connected to the drawbar, carries a stylographic pen, the point of which rests on the paper, and records all movements of the drawbar. This is the wavy broken line on the diagrams, running from right to left.

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ts.

Before starting a test the car is uncoupled at both ends and moved a few feet so as to have the drawbar perfectly free. When in this condition, the recording pen draws a zero or reference line by drawing the paper forward a few inches. A second pen is then set so that it coincides with this line, and for any further movement of the paper traces a zero line. This is seen on the diagrams as a straight line running from right to left. The lower line of the diagrams, with the U-shaped breaks, is traced by a third pen connected to the arm of an electromagnet. The electromagnet is in circuit with a standard chronometer, and every fifteen seconds the circuit is closed and the pen makes a record. At a speed of one mile per hour, the paper travels at the rate of 24 inches per hour, and as the chronometer records every ¼ minute, there will be at this speed $4 \times 60 = 240$ contacts for each mile and each 24 inches of record sheet. From the foregoing, the distance in inches between each contact, is $\frac{24}{240} = \frac{1}{10}$ of an inch; therefore, to obtain the speed in miles per hour, multiply the distance between contacts in inches by 10 and the result is the speed in miles per hour. The upper line of the diagrams is traced by a fourth pen held by the arm of a second electromagnet, which is operated by push-buttons at the windows opposite the record table on either side of the car. It is used by an observer to note the time of passing any points such as mile posts, semaphores, and, in this test, flags. As the paper moves at the rate of 24 inches to the mile, one inch of paper $= \frac{5280}{24} =$ 220 feet, so that the distance between any two points noted may be obtained by multiplying the distance in inches on the record by 220, the result being the distance in feet. The area between the flags, zero line, and drawbar record was integrated with a polar-planimeter. The area divided by the length giving the mean ordinate or drawbar pull, which on being referred to the spring curve, gives the mean pull in pounds.

Description hydrokinetimeter.

The hydrokinetimeter as shown on Plate 2 consists of a reservoir 18½ inches in diameter, 12 inches deep, with a copper float in the center to enable accurate measurement of the volume of water displaced; the different volumes of water displaced indicating the lateral motion of the engine as affected by the different tire arrangements, and before starting it was filled with water. At the end of the run the water remaining in the instrument was measured and the difference represented the volume of water displaced. The instrument was bolted on top of the fireman's shield, which is fastened to the top of the back boiler head.

Results of tests.

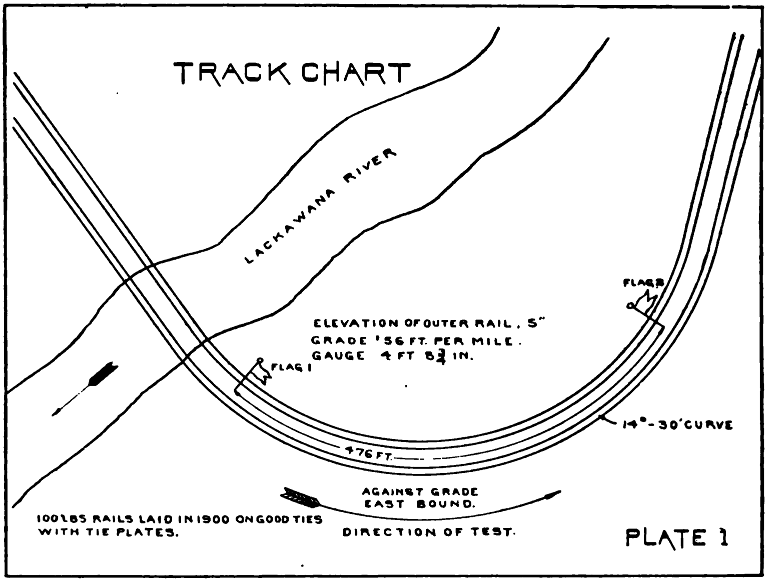
The results obtained justify the members of the committee in concluding that it is desirable to have flange tires on all the drivers of mogul, ten-wheel and consolidation engines. With mogul and ten-wheel engines the tires should be set so that the distance between the backs of flanges will be 53¼ inches. With consolidation engines the tires on front and back pairs of wheels should be set so that the distance between backs of flanges will be 53⅛ inches; with the other two pair of drivers the tires should be set so that the distance between backs of flanges will be 53¼ inches.

It should be understood that the committee assumes that the engines will have swinging trucks.

The members of the committee desire to express their thanks for the use of the dynamometer car, which was kindly furnished by the Erie Railroad.

S. Higgins, Chairman,
W. H. Thomas,
Wm. Garstang,
Committee.

South Bethlehem, Pa., May 2, 1900.



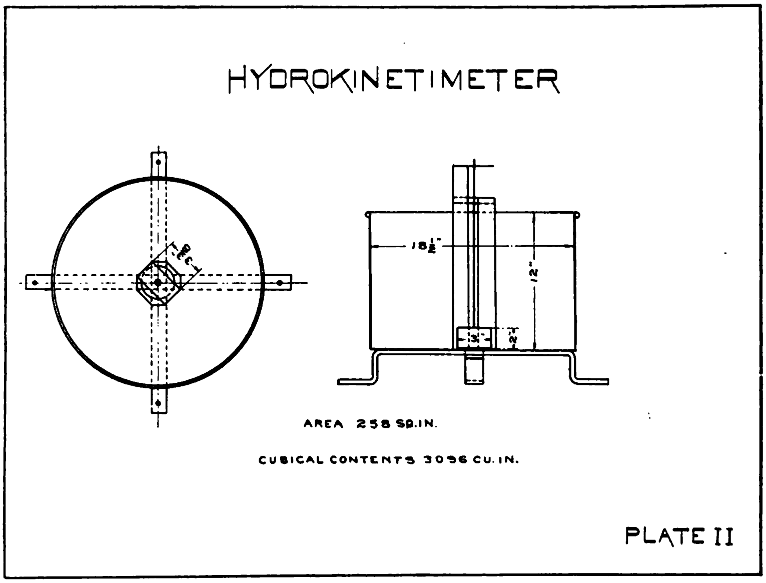
TRACK CHART

ELEVATION OF OUTER RAIL, 5"
GRADE 1.56 FT. PER MILE.
GAUGE 4 FT 8½ IN.

100 LBS RAILS LAID IN 1900 ON GOOD TIES
WITH TIE PLATES.

DIRECTION OF TEST.

PLATE I



HYDROKINETIMETER

AREA 258 SQ. IN.

CUBICAL CONTENTS 3096 CU. IN.

PLATE II

WHEEL BASE ENGINE 710

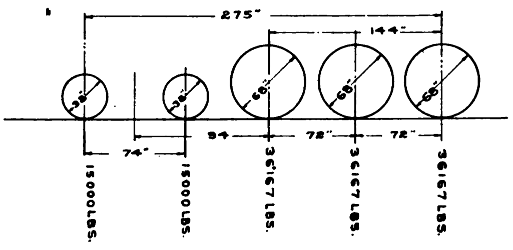


PLATE III

WHEEL BASE ENGINE 689

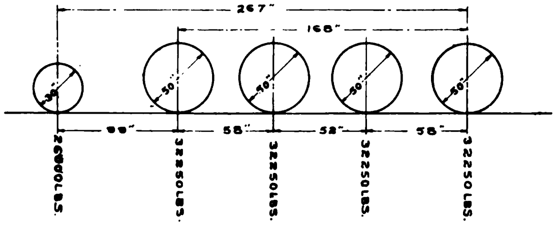


PLATE IV

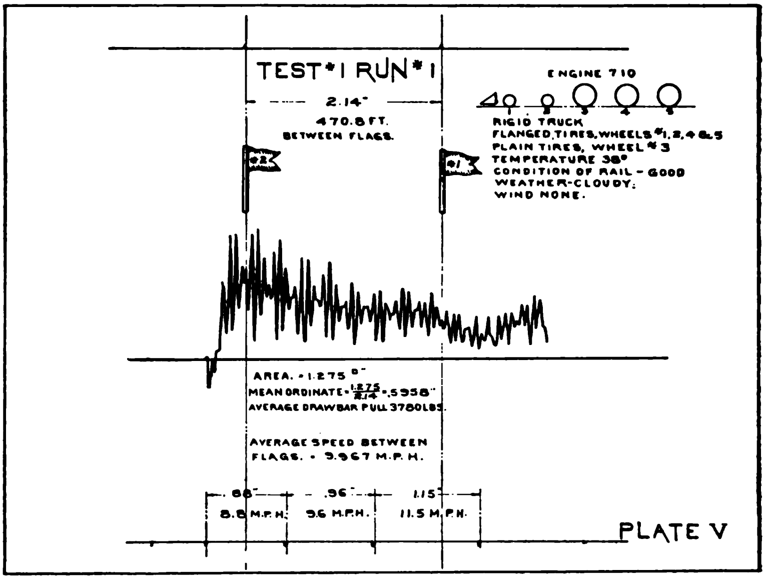


PLATE V

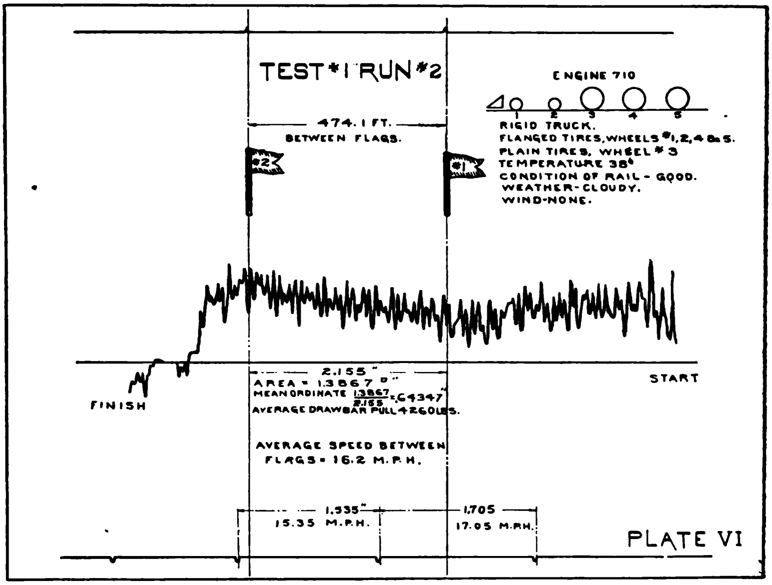


PLATE VI

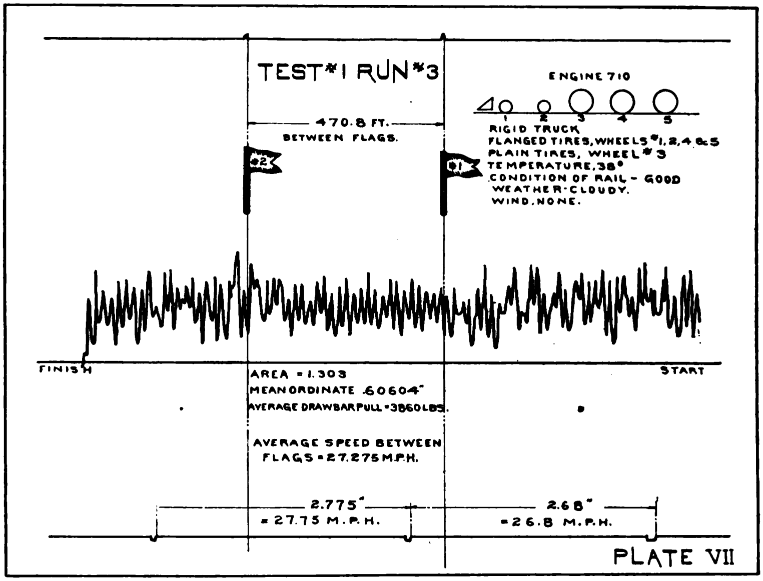


PLATE VII

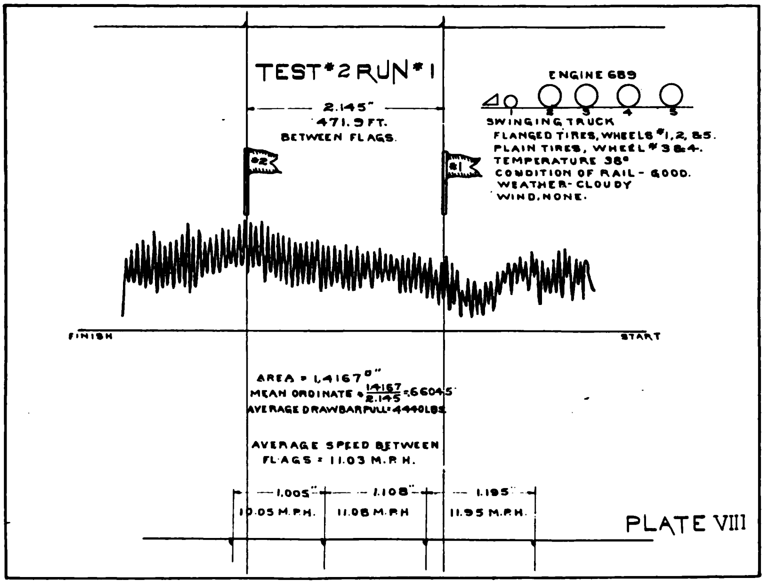


PLATE VIII

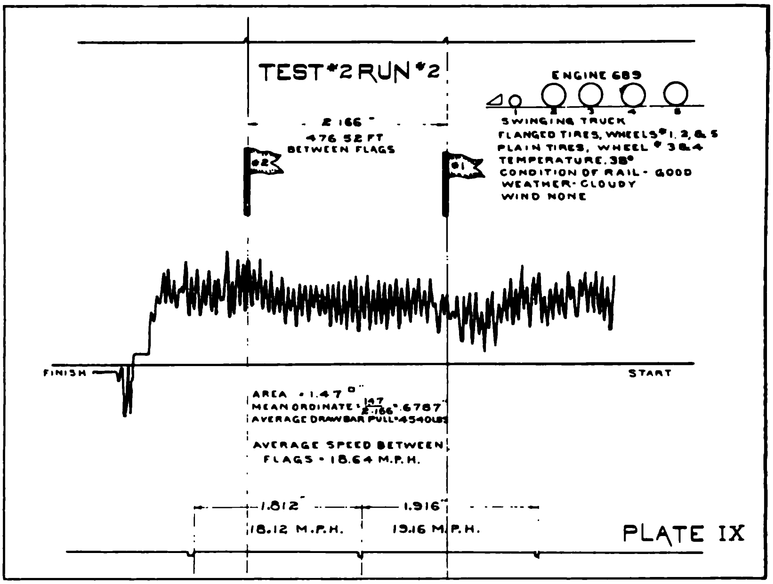


PLATE IX

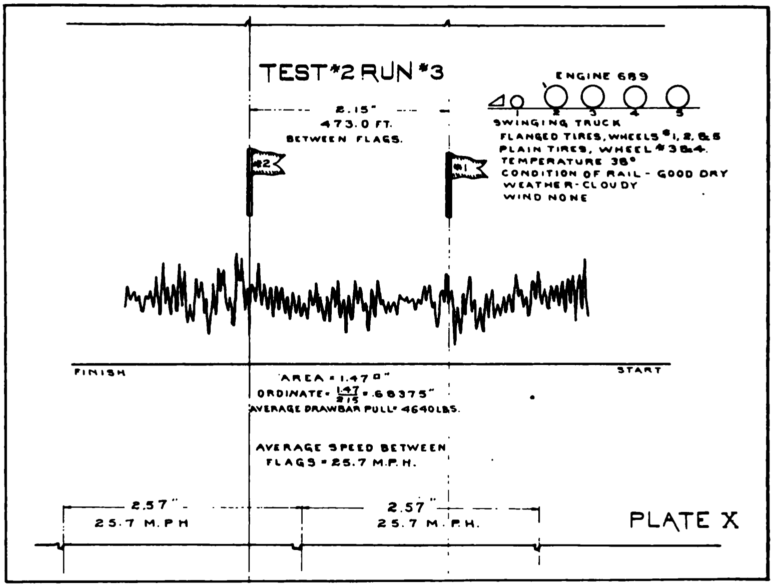
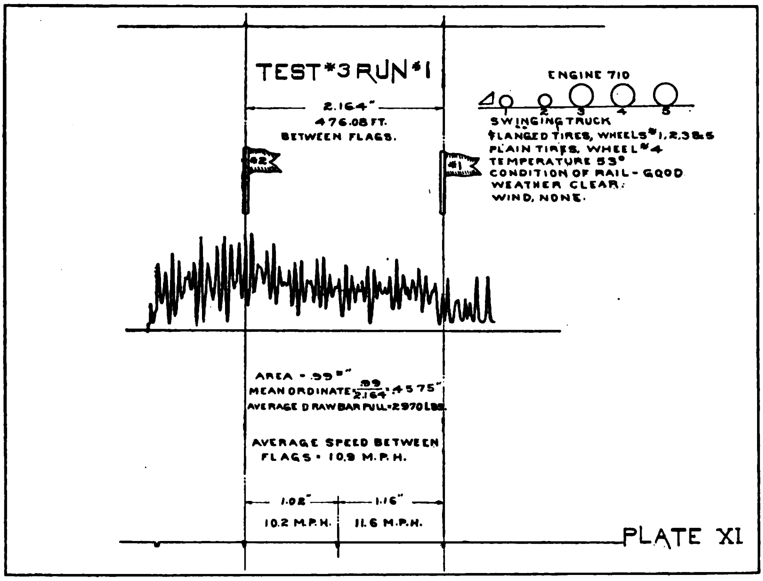


PLATE X



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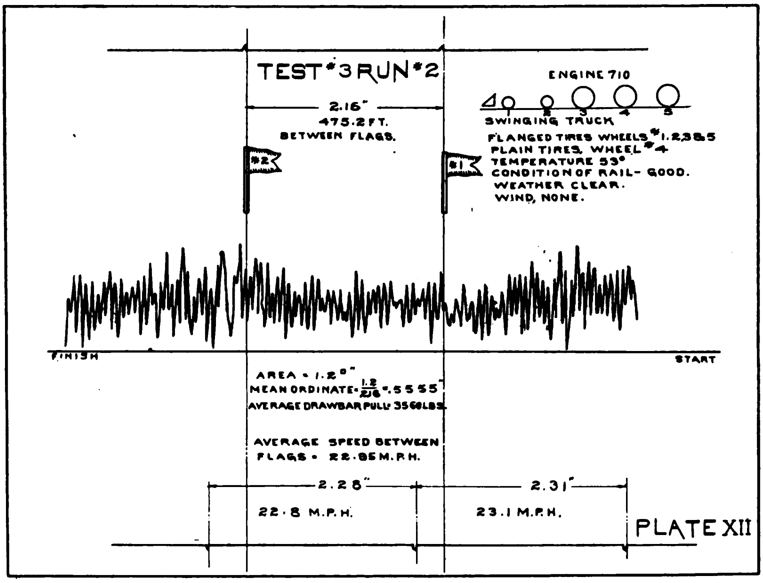


PLATE XII

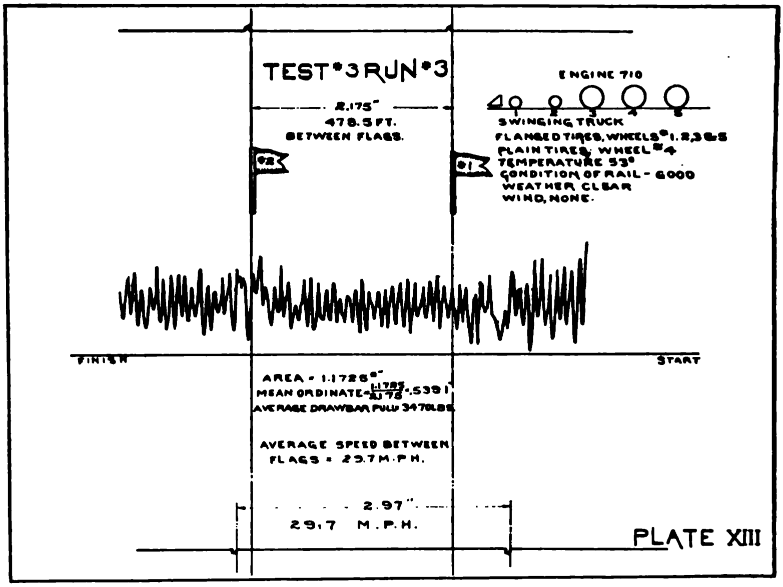


PLATE XIII

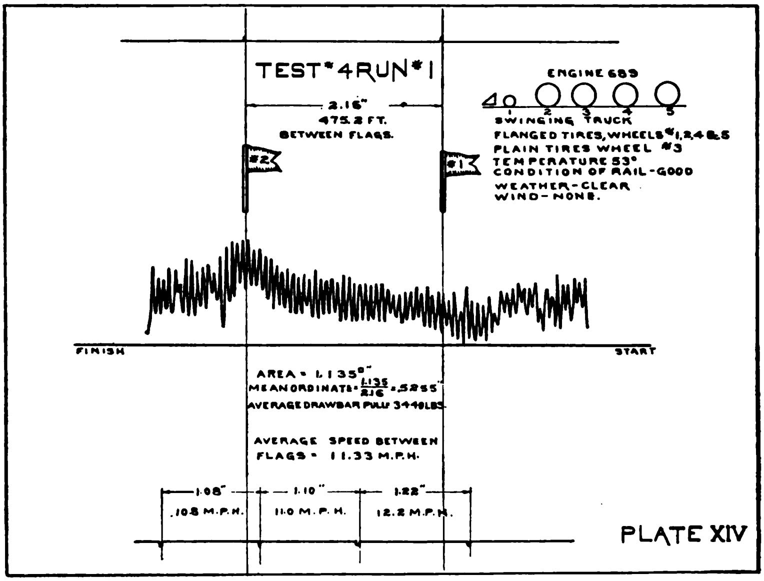


PLATE XIV

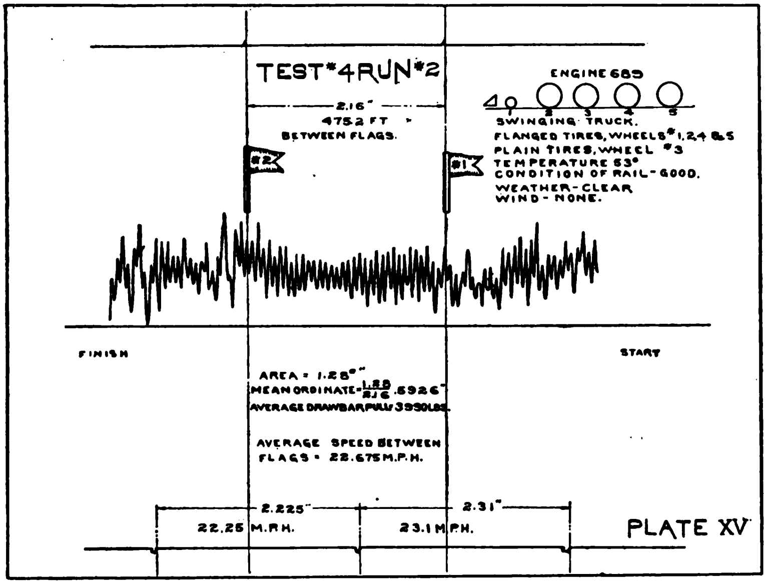


PLATE XV

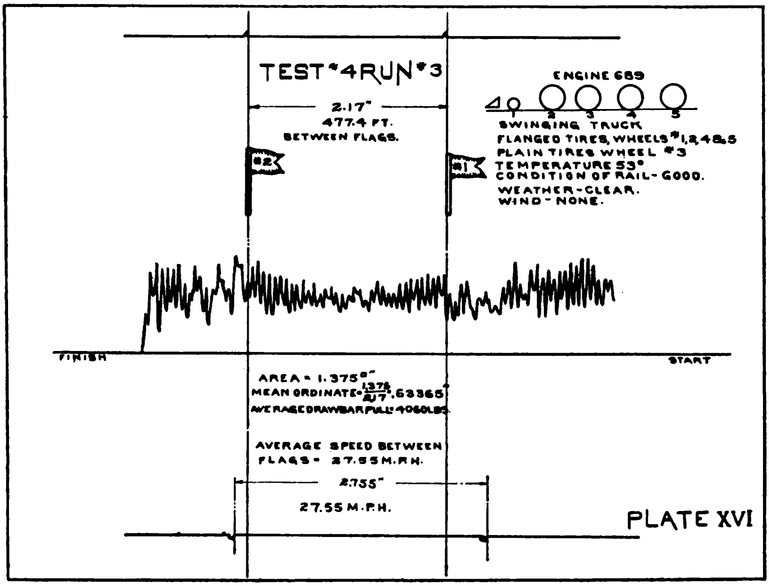


PLATE XVI

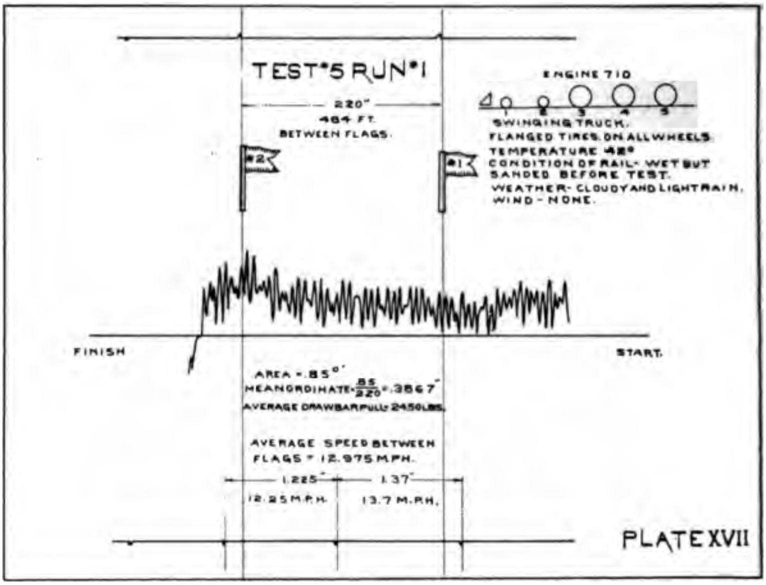


PLATE XVII

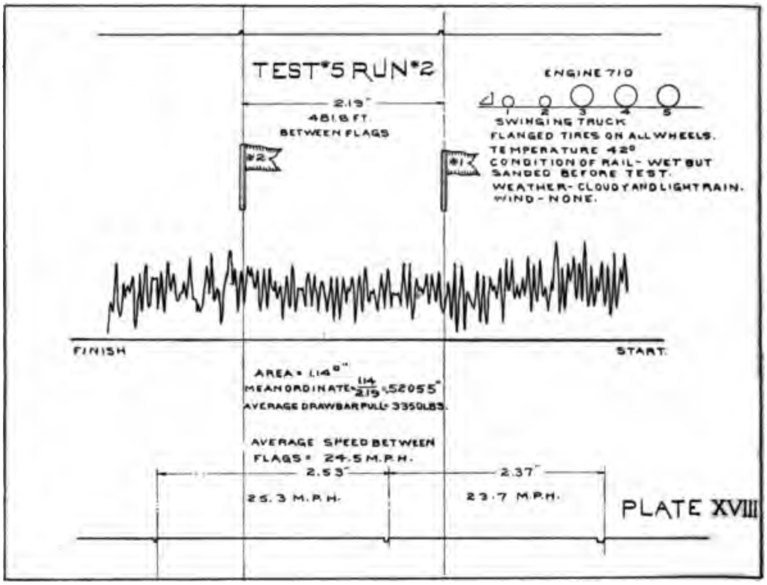


PLATE XVIII

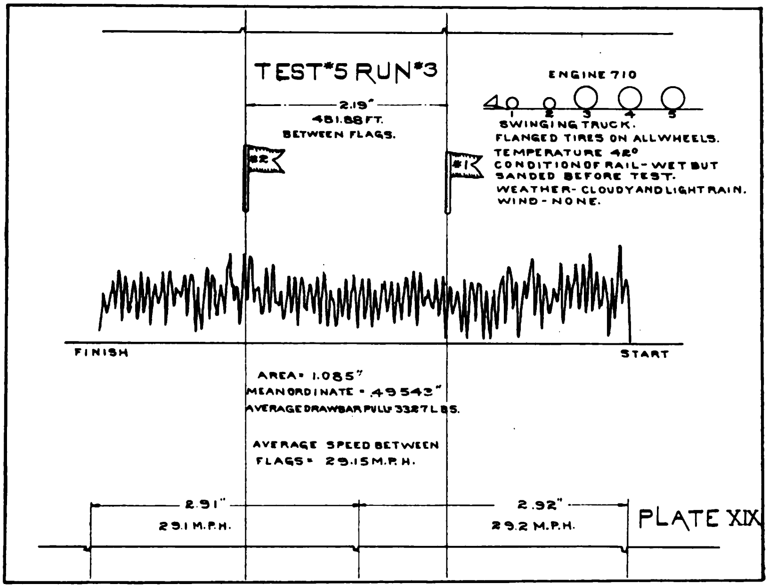


PLATE XIX

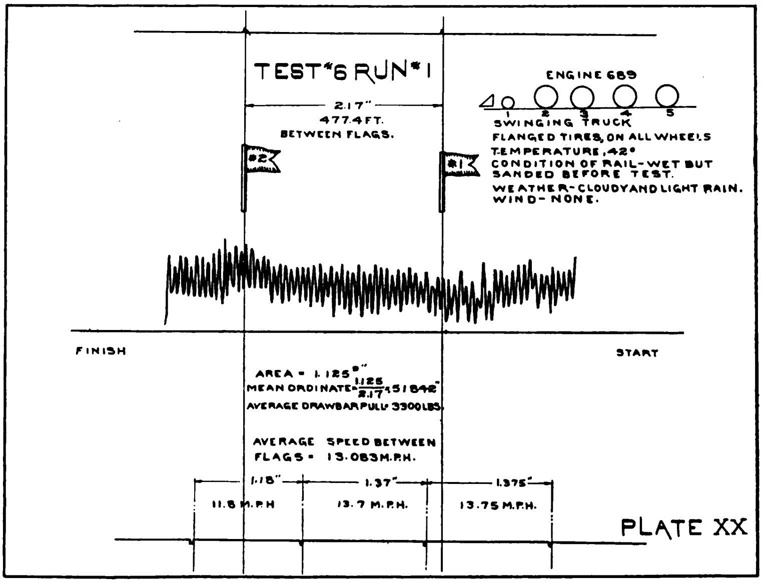


PLATE XX

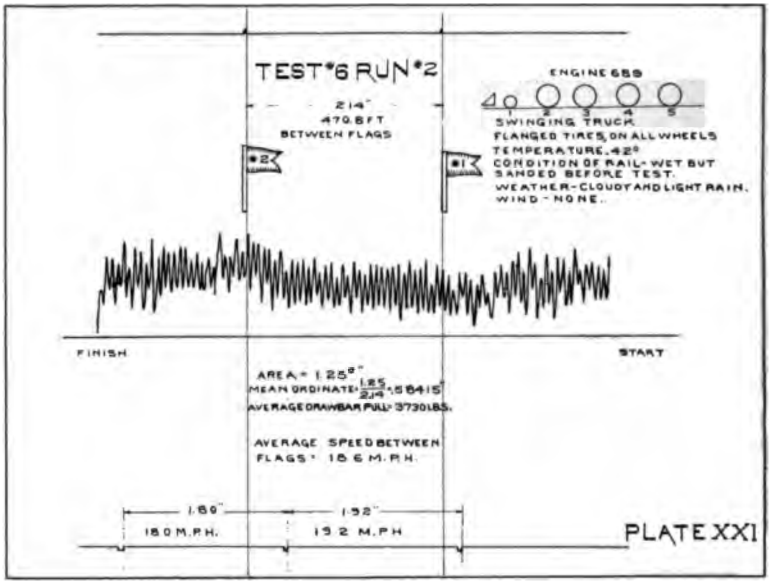


PLATE XXI

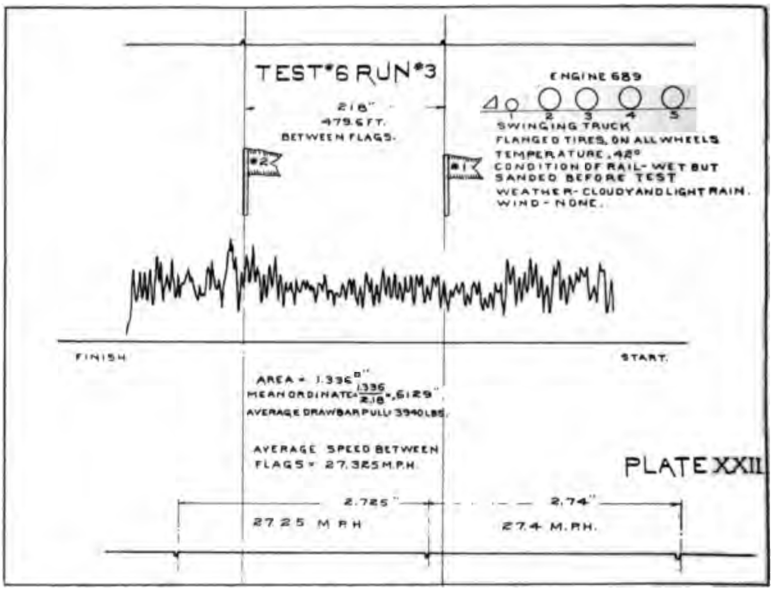
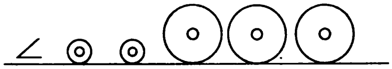


PLATE XXII

PLATE XXIII

SUMMARY OF DYNAMOMETER TESTS.

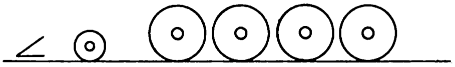
ENGINE 710



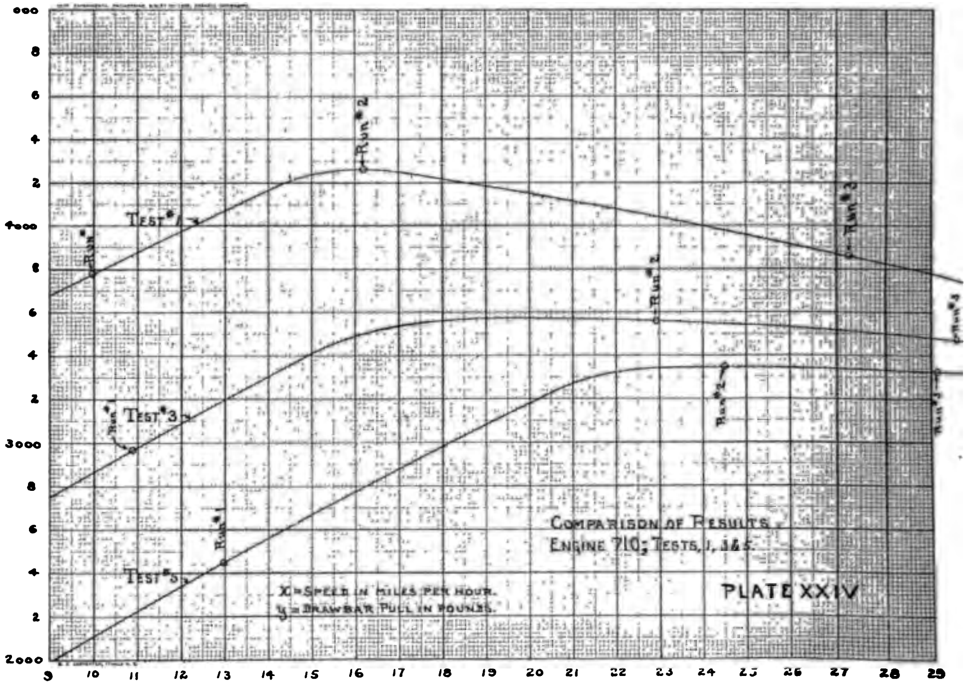
TEST*1			TEST*3			TEST*5		
RUN	SPEED M.P.H.	LOAD POUNDS	RUN	SPEED M.P.H.	LOAD POUNDS	RUN	SPEED M.P.H.	LOAD LBS.
1	9.967	3780	1	10.90	2970	1	12.975	2450
2	16.200	4260	2	22.95	3560	2	24.500	3350
3	27.275	3860	3	29.70	3470	3	29.150	3327
AVERAGE	17.814	3967	AVERAGE	21.183	3333	AVERAGE	22.208	3042

SUMMARY OF DYNAMOMETER TESTS

ENGINE 689



TEST*2			TEST*4			TEST*6		
RUN	SPEED M.P.H.	LOAD POUNDS	RUN	SPEED M.P.H.	LOAD POUNDS	RUN	SPEED M.P.H.	LOAD POUNDS
1	11.030	4440	1	11.330	3440	1	13.083	3300
2	18.640	4540	2	22.675	3990	2	18.600	3730
3	25.700	4640	3	27.550	4060	3	27.325	3940
AVERAGE	18.790	4540	AVERAGE	20.518	3830	AVERAGE	19.669	3657


COMPARISON OF RESULTS.
ENGINE 710; TESTS, 1, 3 & 5.
PLATE XXIV
X = SPEED IN MILES PER HOUR.
Y = DRAWBAR PULL IN POUNDS.
TEST #1
TEST #3
TEST #5
RUN #1
RUN #2
RUN #3
RUN #1
RUN #2
RUN #3
RUN #1
RUN #2
RUN #3
000
8
6
4
2
4000
8
6
4
2
3000
8
6
4
2
2000
9
10
11
12
13
14
15
16
17
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19
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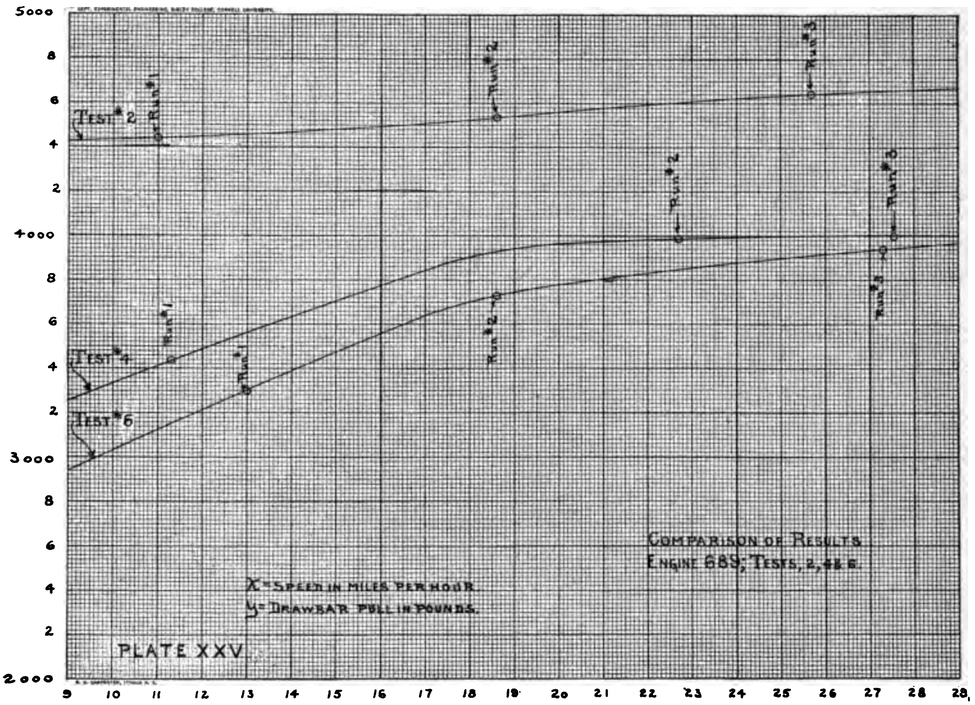
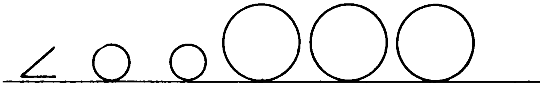

Test #2
Test #4
Test #6
Run #1
Run #2
Run #3
Run #1
Run #2
Run #3
Run #1
Run #2
Run #3
5000
8
6
4
2
4000
8
6
4
2
3000
8
6
4
2
2000
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
X = Speed in miles per hour.
Y = Drawbar pull in pounds.
Comparison of Results
Engine 689; Tests, 2, 4 & 6.

PLATE XXV.

SUMMARY OF HYDROKINETIMETER TESTS

ENGINE 710



TEST NUMBER	*1	*3	*5
AVERAGE SPEED (MILES PER HOUR)	30.86	34.15	33.4
MAXIMUM SPEED (MILES PER HOUR)	40.00	40.60	38.90
HEIGHT OF FLOAT AT START (INCHES)	12	12	12
VOLUME OF WATER AT START (CU. INS.)	3096	3096	3096
HEIGHT OF FLOAT AT FINISH (INCHES)	$6\frac{9}{16}$	$6\frac{1}{8}$"	$6\frac{3}{16}$
VOLUME OF WATER AT FINISH (CU. INS)	1693.13	1580.25	1596.27
VOLUME OF WATER DISPLACED (CU. INS)	1402.87	1515.75	1499.63
PER CENT OF WATER DISPLACED	45.32	48.96	48.44

PLATE XXVI.

THE PRESIDENT: Gentlemen, what is your pleasure with the report?

MR. PECK: I move that the report be received and adopted.

The motion was carried.

THE PRESIDENT: Gentlemen, what remarks have you to make on this subject?

MR. P. H. PECK: I would say, Mr. President, that probably I was the first one in the West to try all wheels flanged on a six-wheel switching engine. I did that to avoid excessive flange wear on the front drivers. Frequently I turned as much as half an inch off of the tires in order to get a good flange on. They have been running about five years and we have not had any trouble on account of excessive flange wear of the front drivers since, and we experience no difficulty in getting around the shortest curves we have in Chicago. If a switch engine is derailed, the first thing it does, if it has blind tires on, is to turn crosswise and possibly tip over.

MR. J. F. DEEMS: I would say that two years ago perhaps, or more, on the part of the road on which I am located, we experimented with flanged tires on all the wheels of a mogul engine, for the same reason that Mr. Peck has mentioned, to reduce the flange wear on the front tire, and it has proven very successful indeed. We have succeeded in running the engine twice as long before it is necessary to turn the tire on account of the flange wear.

MR. D. HAWKSWORTH: We have four consolidation engines on our road weighing about 175,000 pounds on the drivers. These engines were equipped with flanged tires all around. The road has sixteen degree curves and three per cent grades. We found that with our pine ties the track would spread and give us a great deal of trouble, so much so that we put blind tires on the second pair of drivers and made the tire two inches wider than the ordinary width. In this way we got along very much better than when the engines were equipped with all flanged tires.

MR. G. W. RHODES: It seems to me that the point Mr. Hawksworth brings up is an interesting one, because on that particular portion of the line where he used flanged tires on four-wheel connected engines, it was possible to make some estimate and some measure of the damage done to the track. The ties were soft pine ties and the rails were not laid on tie plates, just laid on the ties. On going over the line at one time, the roadmaster, in talking to me about the engines, said that he absolutely could not keep his track safe with those engines, and we did at one period lay up the engines. The reason for this was that he had spiked his ties so much in trying to keep the gauge, that, as he expressed it, he had spiked his ties to death, and as he could not get new ties and he could not get tie plates, things were becoming serious. Therefore for the time being these all-flanged engines had to be dispensed with. I would think that in investigating this matter the track factor that enters into it is not measured up enough on account of the difficulty in measuring it. Therefore the statement that Mr. Hawksworth makes is interesting, as it happened to be on a portion of the line where, owing to the softness of the ties, it was possible to measure the additional strain that was put on the track. In this section of our road pine ties began to rot out in three years and seldom last more than five years.

Mr. David Brown: I am one of the members that have no use for blind tires, and I never used one very long wherever I have been. Where we did happen to get one, the first time the tire was turned we formed a flange, and I have no doubt some of the members have seen the diagram I brought here on different occasions to show them. The practice, for consolidation engines, recommended by the committee, is what we have been using right along, with the exception that we keep the backs of the tires all the same. We reduce the flanges on front and back tires one-eighth of an inch. I think, in addition to the trouble that the member who last spoke had with his roadmaster, that he probably did not have proper elevation in his track and that as much as anything was the cause of running off the track. If the curves have proper elevation there is no trouble with flanged tires. As I said before, I do not see any necessity for it.

Mr. W. McIntosh: Mr. President, I will state for the information of the members that, on the road with which I am connected, we have in service twenty-five very heavy consolidation engines. They weigh 205,000 pounds. We have been operating these a year now with all flanged tires fitted up substantially as the committee recommends, and they are giving excellent service. They neither wear the flanges unduly nor do they wear the hubs of the wheels or face of the driving box to any unusual extent.

MR. WEST: I would like to say that in 1891, on the road with which I am connected, the two middle drivers on consolidation and the middle pair on mogul engines were all bald, and it was almost impossible for us to get 20,000 miles out of the forward tires of the moguls without turning them. We gradually began putting flanges on all drivers, and at the present time all of our engines, both moguls and consolidations, have flanged tires, and we have entirely overcome the trouble from worn flanges. About two years ago we had a train of thirty-five cars get away and run down a grade seventy feet to the mile. The car next to the engine left the track at a very high rate of speed and the entire thirty-five cars went down the embankment. The engineer, before the train separated from the engine, went back to set up some brakes and help stop the train, and he and the conductor and one trainman were killed. After the engine had reached the bottom of the grade we found, on examination, that every pedestal brace was knocked off the pedestals, showing the tremendous speed at which the engine was running down the grade. The grade was full of curves, and, as I say, was a seventy-foot grade; showing that the flanged tire is practically safe.

MR. W. S. MORRIS: Mr. President, I would like to ask the committee if these recommendations were based on experiments on a 4-foot 8½ or 4-foot 9 gauge track.

MR. HIGGINS: The gauge was 4 feet 8½, and before the tests were made the Engineer of Maintenance of Way and his men went over the section of track very carefully and had things in excellent shape.

MR. W. GARSTANG: Mr. Chairman, the test was made on a 14 or 14½ degree curve, and, as Mr. Higgins says, before we went into the tests a letter was written to the chief engineers of various roads getting their standard practice of elevation on curves, and when the replies from all the roads were received, the chief engineer of the Lehigh Valley Railroad Company put this curve up to the average practice in vogue on a majority of roads in the country, which gauged 4 feet 8¾ inches between rails on curves.

MR. QUAYLE: Mr. Chairman, after hearing the committee's report last year I went home determined to make a test of flanges on all driving wheels. We have a place in Chicago known as the "battle ground," one of our switching yards, where we have had considerable flange wear. We placed some tires on the engines doing work in this location where we had most trouble, in accordance with the recommendations of the committee; it has reduced our flange wear, and we think favorably of it. I am interested this morning in what has been said. It seems to me the consensus of opinion is that if the locomotive is properly adjusted and has the proper clearances, and you have the proper elevation and proper gauge of track, that the flange wear is diminished, and yet Mr. Hawksworth says, and Mr. Rhodes explains, that there is a greater strain, it would appear, from the condition of the rails, which is in conflict with the opinions of the others present. If they have a greater strain there, so as to turn the rail over or pull the spikes, there must be greater wear, and there must be some local condition there that caused that trouble, or else we are not right in our conclusions. It would seem to me that the locomotive ought to be overhauled and looked into very carefully to see if the conditions as recommended by the committee of last year prevail in the locomotive, or if the conditions of track as recommended prevail, in order that we may know more definitely about the matter.

MR. W. E. SYMONS: Mr. President, referring to the sentence before the last sentence in the committee's report, by implication it would be unfavorable to the use of flanged tires throughout with a rigid truck on a ten-wheel engine. I would like to inquire of the committee if it can throw a little light on the subject. What would be the results of flanging all tires on moguls or ten-wheel engines, particularly a ten-wheel engine which was equipped with a rigid truck?

MR. HIGGINS: Mr. President, in reply I would say that the committee did not consider that phase of the question, for the reason that it was not able to find that that was the practice on any road in this country. I do not like to answer for the committee. I might answer for myself personally that I do not think the results of that arrangement would be very good. I feel that to make a success with all flanged tires involves the use of a swinging truck.

Mr. Delano: I think there is very little doubt that the committee is right in that they are able to reduce flange wear by flanging the middle wheels of moguls and consolidation engines. But it seems to me that it is done at the expense of the track. For nine years I was in a position where I was more responsible for the track than I was for the locomotives, and I had an opportunity to study that side of the question. It seems to me, if any one stops to think of the position that a locomotive assumes, which has the middle tires bind — whether it be a mogul, or a six-wheel switching engine, or a consolidation engine — he doubtless knows that on sharp curves the blind drivers swing so far over that on very sharp curves it is necessary to put an inside rail on the inside of the curve to hold up the blind tire. Now, what happens if these tires are flanged and are unable to move over? They are unable to assume the position of the chord of the arc; therefore, they must strain the rail, for, of course, the connection of the rail with the ties is more or less flexible. It is perfectly true that if you gauge the track before and after the engine has passed, you may find no appreciable change; but the constant straining that takes place there, I feel certain, is injurious to the rail in slicing it off. In fact I have found on sharp curves long shavings of steel taken right off the rail by the flanges of the wheels. Then there is another consideration: Wherever there is a frog on a curve there is of course a guard rail opposite the switch as well as a guard rail at the point of the frog. The location of a guard rail, under the rules common in the United States, is to make them 1¾ inches from the main running rail; 1¾ inches on standard gauge track on each side makes those guard rails 4 feet 5 inches apart, the rule being to maintain that space at 4 feet 5 inches between those guard rails. As the gauge of the track is increased for curvature, that same 4 feet 5 inches is maintained, and the distance of the guard rail from the running rail is increased; that is, it is made as much more than 1¾ inches as the widened gauge is more than 4 feet 8½ inches. The rule on many roads is to increase the gauge of the track ¼ inch for each five degrees of curvature, and for fifteen degrees it would be 4 feet 9¼ inches. But if any one will lay out on a drawing board the conditions which exist where there is a frog on a curve with a guard rail opposite to it, and then locate his flanged tires on a locomotive with long-wheel base, he will soon satisfy himself that there is a limit of curvature around which that locomotive cannot pass without spreading the track or dislodging the guard rail. For consolidation engines that are used on the C. B. & Q. road I found that limit of curvature to be nine and one-half degrees. I do not know but that the committee may have touched on this point, but it seems to me that there is one way of accomplishing what they seek to accomplish — that is, diminished flange wear — which perhaps will do as much good as any other way without injury to the track, and that is, to make the leading truck, the pilot truck, whether it be a single or a double truck, do more to guide the engine. Of course, with blind tires and a floating truck, the front driving-wheel flange has to do all the guiding. If there is more study of the form of the swing motion in the leading truck it will do a good deal toward assisting the front drivers in guiding the engine.

In answer to one of the questions that was put in regard to the ten-wheel engines with fixed trucks, I think that is not an uncommon thing. One division of the road I am on has ten ten-wheel engines, the double truck of which is equipped with a center pin; the front driver is blind and the two back drivers flanged. Those engines operate on fast trains on sharp curves and they take the curves very smoothly, apparently just as smoothly and easily as any eight-wheel (American type) engine that was ever designed.

MR. WEST: I would like to say, in answer to Mr. Delano, that my observation of tire wear does not bear out his statement of the engine sliding over with the bald tire. On the different roads with which I have been connected I find that the bald tire will wear a crease right down in some portion of the face about the width of the rail, that that spreading of the wear over nearly the entire surface does not take place. I cannot understand how an engine that is easy on the flanges of the tires will be hard on the track. We parallel a road using bald tires on the two middle drivers of consolidation and the center pair of mogul engines. I have been watching the curves very closely the last five or six years and I am sure that the rail wear on our curves is not nearly as much as it is on the other road.

Mr. Johnson: There is one point which is very important that we lose sight of, I believe, and that is, the fact that the flange on the tire is beveled inward, and to that point where it intersects the line which forms the curve or outer edge of the flange is about five-sixteenths taper. Now, if any one would draw from those three points a circle and his chord intersecting those points, he would find that he has, in addition to the clearance allowed by the rules, about five-sixteenths more clearance before the resisting point of the flange will come in contact with the point of a frog. That compensates to a certain extent — not quite — for the space allowed between the guard rail and the main rail opposite the point of the frog.

Another feature is the established fact that the shorter rigid wheel base you make, the better curvature you have. With a rigid truck you have 21 feet from the center of the back wheel to the center of your truck. In curving, those two points fix your chord, and necessarily, being longer than that where the drivers are connected, they are harder on curves. That was my personal experience in pulling the throttle. Since then I have found engines on roads that I have had charge of, where the yardmen were always complaining about their tearing up tracks and tearing out the curves — moving the track as it were. I have moved the flanged tire from the center forward, put in a swinging truck with 1¼-inch straddle outward from the vertical line at the bottom end of hanger supporting the swinging center on the truck, and I assure you that the complaints about moving rails and disturbing the frogs and short curves on side tracks were never heard of afterward. The principle is plain; by reducing the length between the rigid centers you make a shorter wheel base, and the adjustment is that much more convenient. By straddling the lower end of swinging center outward, as the engine curves she throws that center plate outward and upward; this increases the weight on the truck and naturally increases the tendency of the engine to readjust herself to her proper height, which also helps to reduce the wear. At the same time the elasticity allowed by the swinging motion does a great deal to remove the strain upon the rail. In fact, in practice I have found that the bald tire on a rigid center was fully thirty per cent more injurious to rails and curves than are the shorter fixed points at driving centers.

MR. McINTOSH: I would throw out the suggestion, in the way of increasing the freedom in passing curves, to allow more space between the flanges of the driving box. Possibly as much as ⅛ inch of lateral motion could be allowed on consolidation engines without unfavorable results. In fact, I think the results would be decidedly favorable, as the strain on the flanges would be removed, and the boxes moving laterally on the face of the wedges would have a tendency to keep them smooth, in addition to allowing a great deal more freedom in the way of the flanges adjusting themselves to the curvature.

MR. VAUCLAIN: Mr. President, it seems to me that the conclusions of the committee are all right. If you take a consolidation locomotive having a 16-foot wheel base and place it on a 20-degree curve, you will find that the height of the arc in a 16-foot chord on that curve is about 1.32 or 1.35 inches. Therefore if the track is about ¼ inch wide, ¾ inch play, you have 1 inch of that 1.35 already taken up by simple measurement. You have left .35 to provide for, supposing your driving wheel would come exactly in the center. But your driving wheel does not come in the center of that arc, but the two center wheels are spaced on each side of the center line. The distance from the tire to the track at that point would probably be about 3-16 inch less, with the lost motion between the hub of the driving wheel and the box of 1-16 inch on the side. Any one can readily figure up that all of the necessary height of this arc is disposed of. This is true, I think, and is perfectly safe to work upon for all locomotives of modern design up to working on curves up to a 20-degree radius; but once in a while you do get on a railroad — for instance, on the Alamogordo & Sacramento Mountain Railway in New Mexico, which is twenty miles long and has a five per cent grade on it, practically all five per cent; the lowest grade, I think, is about 4 or 4.3. The curves were laid out to be 30 degrees. By the time they were straightened out and put in shape about twenty-seven of them were 40-degree curves, and before they were straightened out we found one curve that was 57 degrees. Now it is impossible for any one to conceive that a consolidation locomotive, the type of engine which was operated on that line, could, with flanged tires on all wheels, curve on that track. It required plain tires 8½ inches wide and the shortest wheel base possible, in order to get this locomotive around those curves and operate it without guard rails. Of course, if there had been guard rails laid throughout the entire length of the line, a plain tire, narrower, would have been sufficient; but on account of the extreme curvature, it was necessary to take up all the available room there was outside of the frames, allowing the tires merely clearance to pass in order to operate it successfully. We have been building hundreds of locomotives in the last three or four years having wheel bases of as much as 16 feet 4 inches, with flanged tires on all wheels, and for all ordinary railroad practice, if the engineer takes the fact into consideration that these engines have flanged tires, I think that guard rails at frogs and switches, etc., can be safely arranged for engines of that kind.

THE PRESIDENT: Mr. Gentry, can we hear from you from the builder's standpoint on the subject of flanged tires?

MR. T. W. GENTRY: I do not think I can add anything to what Mr. Vauclain has said. I have not had experience with engines for roads with curves as severe as those he mentioned. The practice is almost universal with builders, in determining wheel spread in proportion to flanged or rigid base of engines for certain curvature. The practice of flanging all tires is coming more into use on roads without very sharp curves.

MR. DELANO: I wish to correct an impression that Mr. Johnson got from my remarks, and that is, that I am an advocate of the rigid center truck. I am not. What I meant to say was that I thought the method of hanging the leading truck ought to be such as to do more in guiding the engine than many designs of floating trucks now in use.

MR. GARSTANG: Before the subject of flanged tires is disposed of entirely, I would like to call attention to the fact that it took about three days to make this test. It required an engine, an engine crew and a train crew, besides several shopmen, to make change of tires, fuel, oil, etc., and I think this Association should take some recognition of this expense, and instead of the usual vote of thanks which it has been our common practice to give to railroads and others that have assisted us in our work, I would move that the Committee on Resolutions, if one is appointed, get up a suitable resolution tendering the thanks of this Association to the Lehigh Valley Railroad Company and its managers for the valuable assistance given the Association.

The motion was seconded by Mr. Morris and carried.

THE SECRETARY: The Committee on Resolutions, appointed by the Chair, will consist of Mr. F. M. Whyte, Mr. George R. Henderson and Mr. C. J. Mellin, of the Richmond Locomotive Works.

The report of the Auditing Committee is as follows:

To the President and Members of the
American Railway Master Mechanics' Association:

We have examined the reports and accounts of the Secretary and Treasurer of the Association for the past year and find the same correct.

Respectfully submitted,

L. R. POMEROY,
PETER H. PECK,
T. A. LAWES,
Auditing Committee.

THE PRESIDENT: Gentlemen, what is your pleasure with the report of the Auditing Committee?

MR. JOHNSON: I move that it be received and the committee discharged.

The motion was carried.

THE PRESIDENT: We will now take up the report of the Committee on Present Status of Compound Locomotives, and What Is the Best Ratio of Cylinders for Various Classes of Locomotives and Service.

This report was presented by Mr. Deems, and is as follows:

REPORT OF COMMITTEE ON PRESENT STATUS OF COMPOUND LOCOMOTIVES AND WHAT IS THE BEST RATIO OF CYLINDERS FOR VARIOUS CLASSES OF LOCOMOTIVES AND SERVICE.

To the President and Members of the
American Railway Master Mechanics' Association:

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mittee.

Fortunately the title of the subject would seem to indicate quite clearly the duties of the committee, i. e., to collect and present for the benefit of this Association the consensus of opinion as derived from experience with compound locomotives in actual service at the present time, but in order to arrive in a proper way at the "present status" and also to add something to the value of the report for reference purposes, it seemed desirable to introduce a brief résumé of the development and introduction of the compound locomotives, as well as of previous investigations and literature on the subject.

Reduction of waste of steam effected by compounding.

The great source of waste in the use of steam in a single cylinder is the alternate heating action of the entering steam and the cooling effect of expansion and condensation on its walls and the consequent wasteful condensation and reëvaporation of steam. Any expedient which will reduce this waste by preventing the transfer of heat from the steam to the exhaust side of the cylinder without transformation in proper proportion into work, will reduce this loss and increase the efficiency of the machine.

This is effected in compound locomotives by a limited expansion, submitting as far as may be necessary to cylinder condensation and reëvaporation, but then transferring the working steam, both the condensation and the reëvaporation, to a second cylinder, in which the latter portion may either do some work or balance its waste more or less fully.

Adoption of compound for variable conditions complicated by proper cylinder proportions.

The question of adoption of the compound engine for the usual work of the locomotive where speed, pressure or load, either or all, is expected to be variable, is complicated by the fact that it is impracticable to find cylinder proportions which will be permanently suitable. Notwithstanding this difficult feature in design, the demand for larger engines and the thin partition which divides a net profit from a loss in railway operation render it well-nigh imperative that a solution be found for this perplexing problem. The heavier a locomotive, the smaller is the relative boiler capacity that can be supplied.

The limit in steam production once reached, the required gain in power can be attained only by a more economical use of the steam generated, and if the compound has the advantage claimed by its advocates, it seems that it will of necessity be adopted. The advantages accruing from compounding may be summarized as follows:

Advantages of compounding.

1. Reduction of expansion in one cylinder and consequent reduction of internal waste.
2. Ability to adopt large ratios of expansion with light loads without wire drawing.
3. Reduced leakage in engine.
4. Reduction of depreciation of boiler.
5. Greater boiler efficiency.
6. Lighter blast, smoother draft, less waste, annoyance and danger from sparks ejected from locomotives.
7. Elevated limit of speed and power.
8. Reduced loss by tender and fuel haulage.
9. Greater uniformity of crank movements.
10. Larger efficiency of machine.

Disadvantages of compounding.

To offset these gains, there are losses which may be enumerated as follows:

1. Increased first cost.

2. Increased cost for repairs and maintenance of machinery due to multiplicity of parts and greater weight of reciprocating parts.

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pounding.

Realizing the theoretical gain due to compounding, Mr. Roentgen, a Dutch engineer, made the first attempt at compounding in 1834. His locomotive was of the two-cylinder type, with a small receiver in the smoke box, but it never came into practice, probably because of the undeveloped state of steam transportation at that time.

M. Jules Moramdieres, a French engineer, in 1866 designed a three-cylinder compound with two groups of driving axles, connected by outside rods. One group was driven by one inside high-pressure cylinder, while the other group was driven by the two outside low-pressure cylinders. Live steam was used in all of the three cylinders in starting.

The first four-cylinder compound was proposed by Mr. William Daws, of Leeds, England, in 1872. Double crank pins were used so that each cylinder had a separate set of rods. Live steam was used throughout in starting.

While these locomotives did not prove a success they contained the germs from which the modern compound locomotive has sprung. As different men working out the same problem will develop it on different lines, so has the compound locomotive taken different forms which may be classified as follows:

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Two-cylinder receiver, without separate exhaust for high-pressure cylinder and automatic starting gear.

With intercepting valve:

1st. Von Borries (early).
2d. Worsdell.
3d. Schenectady (early), Pitkin.
4th. Dean.
5th. Baldwin (early).
6th. Brooks, Player.
7th. Rogers.

Without intercepting valve.

1st. Lindner.
2d. Golsdorf.
3d. Cook (early).

Two-cylinder receiver, with separate exhaust for high-pressure cylinder; optional starting gear with intercepting valve:

Mallet.
Schenectady (new).
Richmond, Mellen.
Rhode Island, Batchellor.
Pittsburgh, Colvin.
Von Borries (latest).
Baldwin (latest).
Cook (latest).
Rogers (latest).

Four-cylinder tandem compound, two crank, no receiver:
- Dunbar, Boston & Albany.
- DuBousquet, Woolf.
- Baldwin, Vauclain.
- Johnston.

Four-cylinder tandem, two crank, receivers:
- Hungarian, state.
- S. W. Russian, Mallett.
- Brooks.

Three-cylinder, three cranks:
- Webb.
- Northern Railway of France.

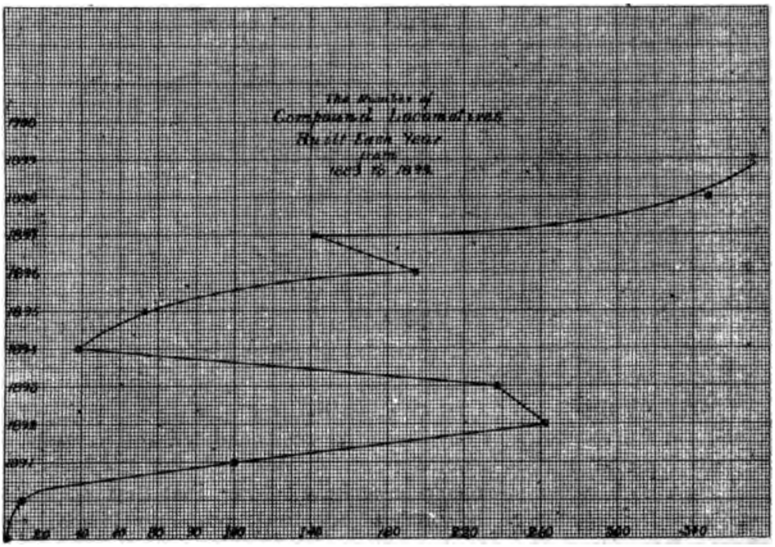
This classification is based upon that given by Mr. Wood in his work on Compound Locomotives.

Number of compounds built yearly.

Although the first compound locomotive was designed in 1834, and Mallet, in Europe, brought out successful compounds on the Bayonne & Biarritz Railroad in 1876, it was not until the year 1889 that the American builders constructed a compound locomotive. From that time there has been constant increase in the number built, interrupted only in 1894 and 1895, probably by the panic, until, in the year 1898, the number of compound locomotives produced was over thirty per cent of the total output in several plants, and in 1899 forty-five per cent of the total output of one prominent company was compound.

The growth in numbers and the interrupted progress is seen in the table showing the total number of all types turned out each year by the builders in the United States, and in the accompanying curve.

1889	2
1890	9
1891	100
1892	263
1893	237
1894	38
1895	73
1896	195
1897	142
1898	348
1899	371
Total	1,778



These figures do not include the compounds built by different railroads for which the different locomotive works might or might not have furnished cylinders.

Before the advent of the compound locomotive in this country, its introduction on the London & North-Western Railroad had attracted the attention of Master Mechanics, and in 1882 a paper on the Webb compound was read at the annual convention of the American Railway Master Mechanics' Association.

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Nothing further was done until 1890, when the report of the committee on compound locomotives was presented to the convention by Mr. J. Davis Barnett. This paper was based upon information obtained from roads in countries other than this, owing to the slight experience of American railroads with the compound locomotive. In this report it was shown that there was a gain due to compounding at what are now low pressures. Thirteen advantages due to compounding were given and six losses. The increased first cost was considered, and the following statement, made by M. Von Borries, was quoted:

"Compound engines can be built two to five per cent cheaper than singles of the same power, not of the same tractive force, because this power depends upon the boiler, which might be ten to fifteen per cent smaller for the compound engine. If the same boiler is kept, as is commonly the case, the compound engine would be some two to three per cent heavier and four to five per cent more costly than a simple one, but with properly dimensioned cylinders, ten to fifteen per cent more powerful than the latter. For equal work the compound engine would always be the cheaper. However, the cost for repairs might, where fuel is very cheap, make the compound more expensive than a simple engine."

In the discussion it was developed that Mr. Worsdell's figures for English practice show that the compound does not increase the cost of repairs.

At the convention in 1891 the question again came up in the form of a topical discussion, in which it was shown that the compound was more economical in fuel than the simple engine and the relative advantages of the two and four cylinder types were brought out.

Mr. Smart stated that on the Canada Southern Division a two-cylinder compound was pulling their heaviest and fastest passenger train and making better time than any simple engine they had in service.

The report of the committee on compound locomotives presented in 1892 was based upon comparative tests between a simple and a compound engine, identical in every respect with the exception of the features necessary to the compounding. These tests were very complete and indicate that with Pittsburg coal the compound shows a gain of 7.06 per cent. In conclusion, the committee stated that "it seems probable, as a general review of the entire question, that the results given with the Pittsburg coal represent the simple engine in its most favorable condition. On the other hand. they are strongly of the opinion that the large number of trips represented by the tests with Braceville coal quite nearly approximate the condition laid down as most desirable at the outset of the report; that is, average monthly or yearly economy to be derived from compound engines. This figure is shown to be 16.9 per cent coal and 14.1 per cent water economy."

The uniformity of rotative effort of the compound *vs.* simple is shown by the dynamometer cards accompanying the report, each engine showing a more uniform effort at one certain speed, and this speed is different for the two engines under consideration.

In 1893 the committee on compound locomotives presented a report based upon data obtained from as many different sources as possible, in an attempt to more completely cover the field. No better synopsis of the report can be given than the conclusions drawn by the committee from the data collected by them.

"Your committee therefore offers tentatively, the following opinions and suggestions:

Opinions of committees, 1893.

"1. The compound is suitable for a variable class of freight service.

"2. Its range of economy in such service is fully as wide as that of the simple.

"3. Its increased coal economy over the simple in the average freight service of the country will be found to lie between ten and fifteen per cent when in good running condition and handled with intelligence.

"4. A well-designed compound should not be more difficult to keep in a serviceable condition than a simple; that is, its regularity of performance should not be less than the simples.

"5. The four-cylinder compound will cost more for valve oil than a simple.

"6. The running repairs of a four-cylinder compound will be somewhat more than for a simple; for a two-cylinder compound they should not be more; the final comparison for repairs is undetermined.

"7. The net running cost of a compound will be less on many roads than of the simple, the figure depending upon the design, cost of fuel and other local conditions.

"8. In passenger service the availability of the compound is undetermined.

"9. Complicated designs of compounds are not likely to prove desirable nor economical. The prevailing forms of starting valves in use in this country are especially noted as being too complicated. Certain valves employed abroad seem to have more commendable points.

"10. Attention is called to the necessity of long tests and averages of a considerable number of exactly similar engines of both types to properly establish the status of the question. In such tests the influence of higher pressure for either type should not be allowed to complicate the results, as the effect of the highest modern steam pressures on economy of the simple is undetermined."

In the discussion which followed the reading of the report, it was generally conceded that the conclusions were reasonable and upheld by experience.

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In 1894 the subject was brought up in the form of a discussion which, with one exception, was favorable to the compound.

Mr. R. H. Soule stated that the Norfolk & Western Railroad had determined that the cost of cylinder repairs constituted but two and three-fourths per cent of the total cost of maintaining a locomotive.

In 1895 the same topic was under discussion and attention was called to the necessity of simplicity of design. It was generally concluded that the compound was a good engine for freight service, and Mr. Vauclain stated that it was clearly brought out on the Central Railroad of New Jersey that the high speed compound passenger engines with narrow fire box for anthracite coal were more satisfactory than the single expansion engines.

In 1897 Mr. Morris gave comparative figures between ten simple engines and one compound of the same class. "The compound, in four years, made 19.2 per cent more miles per ton of coal, and ran 30.9 more miles per pint of oil. The cost in cents per mile run for repairs was .9 of 1 per cent more, and for oil and waste 8 per cent less; fuel per mile, 21.3 per cent less for the compound, and the total less cost per mile of 8.4 per cent as compared with the ten simple engines for four years."

Mr. George Gibbs stated that "the gain of the compound over the simple engine of the same build, and exactly similar, varies from 17.5 to 25 per cent; that they are not as powerful a machine to start as simple engines, but after a speed of seven or eight miles per hour had been obtained they are much smarter, and at high speeds for express service they are a much smarter engine and do their work better than simple engines."

Mr. Quayle made some tests with a view of determining the proper cylinder ratio, in which tests a constant horse-power was developed, constant steam pressure and constant speed, and determined that a ratio of two and one-half gave the best result.

The tenor of the remarks would indicate a preference for the compound.

The question of automatic control of the compounding feature *vs.* manual control was also discussed at this convention, and the almost universal opinion expressed was that manual control was preferable.

After a careful consideration of the question as it has been presented before the Association in previous years, it would seem that there has been a steady growth of sentiment in favor of the compound, not only for slow freight, but also for express service; that many of the failures in its early days were not those of a wrong principle, but of faulty design, which source of trouble has to a large extent been remedied.

Relative performanc compound simple engi

In recent years the number of compound locomotives which have been placed in service by the different roads has made the possibility of obtaining comparative data as to their performance, relative to simple engines, rather less difficult than formerly. Many roads using both types of engines have tabulated the performance of their engines for long periods of time and in several cases exhaustive tests have been made to determine their relative merits. In view of this fact, the present committee did not feel called upon to treat the subject from this standpoint, but rather to determine as far as possible the general opinion concerning the compound among those having them under their care, and to secure figures showing what net gain, under actual service conditions, might be due to compounding.

The results of a test on the Chicago & North-Western Railroad were presented to the Western Railway Club in September, 1895, by Prof. Storm Bull, showing a saving of coal by the pound of 7.74 per cent, the conditions under which the test was made being more favorable to the single expansion engines with which comparison was made.

The cylinder performance of the compound locomotive at high speeds was carefully investigated by Prof. R. A. Smart, of Purdue University, the results of the test appearing in the proceedings of the St. Louis Railway Club for February, 1898, and would indicate that the compound is suitable for high speeds, and exhibits a saving in fuel consumption of from eighteen to thirty-three per cent.

In the proceedings of the same club for November, 1898, Mr. Vauclain states that the results of Professor Smart's experiments are the technical proof of the determination in actual service, and cited examples of what has been done in high-speed passenger service.

In the proceedings of the Western Railway Club for March, 1899, appears a paper by Mr. E. M. Herr, giving the record of compound locomotives on the Northern Pacific Railway. The paper is of particular value, as the records cover a considerable period and are compared with the records of simple engines of the same class for a similar period. Mr. Herr states "the object of the paper is to endeavor to bring out some discussion as to the advisability or inadvisability of the use of compounds for heavy freight service. From my experience on the Northern Pacific road, my judgment is that it is advisable to use the compound locomotive in heavy freight service. I say advisable because of the economy in fuel, and as far as our experience went, no appreciable, or at least no important, increase in the cost of repairs. It certainly seems advisable to use a machine that shows a saving of from fifteen to twenty per cent of fuel in regular service and no very great or even appreciable increase in cost of maintenance."

In the discussion which followed the reading of this paper, the subject of the advisability of using compounds for passenger service came up, and the prevailing opinion was that for fast heavy service they were economical engines to use. Attention was called to the fact that as the compound was a comparatively new machine, careful attention should be given it, the cause of failure in any part should be determined and the evil remedied; that the most of the failures are not those of the compound feature, but of parts common to both types of engines, but which in the compound might require a design differing from that common to good practice in the simple engine.

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In order that the committee might arrive at some definite conclusion as to the position which the compound locomotive occupies at the present time, about 730 circulars of inquiry were sent to the proper officials of the various railroads and to others by whom it was thought some light might be thrown upon the questions under consideration. The number of replies, however, did not come up to the expectations of the committee, only about thirty being received, but owing to the fact that many roads have had no experience with compounds, this is perhaps not surprising.

As the object of this report is not to exhibit the advantages but to determine the actual value of the compound in railway economy, the absence of replies from roads having unfavorable experience with the compound is to be regretted, and it is reasonable to suppose there is not an entire absence of such experiences. We wish, however, to express our thanks for the very full reports received from some members, many of which appear in the appendix.

The questions contained in the circulars and the replies were as follows:

1. Have you at any time had any compound locomotives under your care; if so, how many and what class?

Compound locomotives of all classes have been in use and there have been reported in freight service:

142 four-cylinder.
191 two-cylinder.
104 not classed.

Total, 437.

2. How long have you had experience with compounds?

In freight service..............................
In passenger service...........................
In switching service...........................

The longest period in which any road had such experience was ten years, and their first engine was a ten-wheeler with a Wootten boiler. The average term of experience with compounds in freight service is about seven years. Five years marks the limit for passenger service, and in the year 1897 their presence in such service became quite marked. There does not seem to be any general use of the compound in switching service, probably because it is not so quick in starting or stopping as a simple engine.

3. How much do you estimate fuel economy per ton-mile or per trip (if car-mile basis is used, give method of equalizing loads and empties), or what saving by compounds in switching service; or are they used in this service solely to diminish noise around large stations and not with a view of saving fuel?

Two roads report that there is no appreciable saving by the use of the compound. Twelve report a saving varying from 8.9 to 30 per cent with an average of 16.6 per cent. The economy is based, usually, on the ton-mile system, and where the car-mile is used as a basis, two empties are equal to one load. For switching service there is only one favorable report. Four state that they are not satisfactory and ten make no reference to the matter.

4. In what service do compounds show greatest fuel economy, and is this item materially influenced by the gradients of the line; and if so, on what character of road may they be used to greatest advantage?

In two replies it was thought that the character of the road did not make any difference in economy; ten replies indicate a preference for the use of the compound where the pull is continuous and the engine would be worked well up to the limit. In one reply a road having a few short, heavy grades would be most favorable to the compound. Where any distinction was made between freight and passenger service, it was stated that freight service showed the greater gain.

5. Are compounds as flexible or as readily adapted to various kinds of service as simple engines of the same class?

Ten report that they are not as flexible as simple engines; five report that they are as flexible with the exception of switching service, and one reports that they are more flexible.

6. Is it your practice to use larger drive wheels on compounds than on simple engines?

In freight service............................
In passenger service..........................

Fifteen report that there is no difference in size between the drivers of the compound and those of a similar simple engine; one reports that the drivers of the compound are slightly larger both for freight and passenger service.

7. If pooling of locomotives and crews is practiced, are compounds pooled or assigned to regular crews?

One road reports having had no experience; two assign regular crews where pooling is practiced with the simple engines; two do not practice pooling either with simple or compound, and ten treat compounds the same as simple engines, pooling them.

8. Is the train rating of compounds in freight service higher than simple engines of the same weight, class and steam pressure? Give percentage of increase if any.

One road reports no experience, thirteen make no difference, and two make a slight increase for the compound. One makes the increase seven per cent.

9. If such rating is higher, is it with the idea that the engines will be worked simple over maximum grades?

All answer yes.

10. What do you consider the correct ratio for volume of cylinder?

For freight service...............................
For passenger service..........................

For two-cylinder compounds in freight service the minimum ratio is 1 to 1.5; the maximum, four out of eight prefer 1 to 2.5. The average is 1 to 2.328. For passenger service the maximum is 1 to 2.5; the minimum is 1 to 2.125; average, 1 to 2.375. In the four-cylinder compounds, the preference is about 1 to 3, a variation being permitted so that the diameters of the cylinders may be conveniently measured.

11. Some compounds are built so that under ordinary service conditions the change from simple to compound is effected by automatic intercepting mechanism, while with others it can only be done manually. Which type do you prefer, and give reasons for preference?

The automatic is preferred in three cases, as its use eliminates the chance for abuse by the engineer. Eight prefer manual control of the compounding feature, as by this method the engines start better and are stronger and are more flexible as regards power, thus enabling an engineer to help a heavier train over a ruling grade or prevent stalling under adverse conditions. Two prefer to use the automatic feature in starting, but yet give the engineer power to use the engine simple when emergency demands it.

12. Have you experienced any trouble from large cylinders drawing

in smoke-box gases, drying up lubrication, cutting valve seats, cylinders, etc.?

Fourteen have experienced no trouble of serious nature, while two have experienced such trouble.

12½. Is there less danger of setting out fires from stack of compounds than simple engines?

Universal opinion is that there is less danger of fire from this source. In one case the danger from the compound being estimated at fifty per cent less and another ninety per cent less than with the simple engine.

13. Do you relieve cylinders while drifting down hills, into stations, yards, etc., and in what way?

In one case no merit is found in relieving cylinders and in another the by-pass is not satisfactory. Of the remainder, those using four-cylinder compounds relieve the cylinders by means of relief valves, and those using the two-cylinder type use the by-pass. Slightly opening the throttle is also resorted to in a number of cases.

14. Have you used slide or piston valves on compounds? If so, in what way and with what results? If experience with both, which do you prefer?

Seven report that they are using the piston valve. Three report that they use the slide valve. Five report using both types, but that the piston valve seems to give more satisfactory service as regards strain on the valve motion and wear of valve seats. On one road it was found the slide valve gives the least trouble. In some cases there have been broken eccentric rods and they have been in all cases on engines of the piston-valve type.

15. Do the compound and simple engines between which comparisons are made carry the same steam pressure; if not, please give difference?

In general the same steam pressure was carried on both types of engine. In fourteen out of seventeen reports the engines compared carried the same steam pressure.

16. To what extent are compounds worked simple?

It is necessary in starting to work the engine simple, and six advise working the engine simple over heavy grades to prevent stalling.

17. Do not engineers work compounds simple to a much greater extent than instructions contemplate?

Thirteen think the privilege of changing to simple is not abused by engineers; four think the privilege is abused.

18. Are compounds out of service for repairs more than simple engines? Give comparative figures, if possible.

Eleven report that the compound is not out of service more than the simple and six report that it is out of service more than the simple.

The parts needed for repairs on a compound are often not at hand, as they differ from the standard of the road. In this way time is often lost. On one road it was found necessary to close the guides more often on the compound.

19. Do you consider cost of maintenance of boilers less for compound than simple engines carrying same steam pressure? State approximately the difference.

Four find no difference in the cost of boiler repairs, seven think they are less but do not state how much, and five give the percentage saved as varying from 10 per cent in one case to 28 per cent in another, the average being 19.6 per cent.

20. Do you find cost of maintenance of machinery more; if so, about what percentage?

Five find no difference in cost of maintenance of machinery; six state that compounds cost less in this respect, and four give the increase at from 11 per cent to 50 per cent, the average being about 25 per cent more.

21. Do you find cost of lubrication more, and how much?

Five find no difference in cost of lubrication; three find that the compound costs less; two state they cost more and five that the compound costs from 10 per cent to 25 per cent more than the simple engine, the average being 18 per cent.

22. Might not the ratio between increased cost of maintenance and decreased cost of fuel consumption make the compound an economical or uneconomical machine as the cost of fuel is high or low in different localities?

Ten replies state that the compound is always economical and can be so used whatever the cost of coal, one stating that with the compound a cheaper fuel can be used and another that the compound, while always showing a saving in per cent of fuel saved, it could be used to the best advantage where the cost of fuel is high. Five think the condition stated in the question is quite true.

23. What is the average cost of coal per ton where you are using compounds?

Compounds are used which burn fuel costing from 70 cents a ton to $3 a ton, the average being $1.64. The road using the 70-cent fuel has fifty-eight compounds in service and that using fuel worth $3 has but twenty-two compounds.

It might be of interest to compare the number of compound locomotives, the percentage of the equipment which they constitute, and the cost of fuel.

COST OF FUEL PER TON.	NUMBER OF COMPOUNDS.	PER CENT OF EQUIPMENT.
$0.70	58	14.00
.75	25	7.69
.80	39	5.30
1.05	47	20.00
1.38	84	9.00
1.50	13	3.12
1.65	97	17.20
1.85	66	7.80
1.85	4	.59
2.00	6	3.80
2.22	31	32.00
2.25	2	15.40
2.40	1	.52
2.70	140	46.00
3.00	22	8.90

In a general way it may be stated that where coal is most expensive, there the compound is in greatest favor, as shown by the above figures. However, the personal element of progressiveness enters so strongly into the question that the figures may have little actual comparative value.

23½. Is there any difference between size of exhaust nozzle of compound and simple engines of same power, and in favor of which?

In nine cases no difference in size of the nozzle is made, and in five the difference is in favor of the compound. In one or two instances the nozzle of the compound was reduced in diameter to improve steaming of engines.

24. Have you made any careful dynamometer or indicator tests of compound engines? Please give extent of such tests and results obtained, showing comparisons with simple engines, if any were made.

It is not possible to give, in short compass, the results of the tests that have been made, and the records of such tests as have reached the committee will form part of this report.

25. There has been a great increase in size and power of simple engines recently. Is it practicable to build compounds of corresponding hauling capacity without encountering great difficulty from pistons and cylinders at high-piston speeds?

Nine of the replies indicate that it is practicable to build compounds of similar size and power to the largest simple engines which have been recently built. Two think it is not possible and the remainder do not express an opinion.

26. What is the best material and designs for low-pressure pistons?

Twelve indicate a preference for the cast-steel piston of the "Z" pattern; two prefer the piston having a bull ring, the one preferring cast iron, the other cast steel; one thinks the cast-iron solid-head piston is the best.

27. State in general terms what you consider the more important improvements that have been made in connection with compounds since

their introduction, both as to construction and the assignment or disposition of the engines in service?

Answers to this question may be divided into three classes:

(1) Improvements in those parts directly connected with the compound feature. These improvements are improved construction of the intercepting valve and the use of an over-pass valve which relieves the low-pressure piston when drifting, improved cylinder ratios, the use of the piston valve, the use of the two-ported slide valves, and the manual control of the compound feature, either in starting and emergency or in emergency alone.

(2) Improvements necessitated by the introduction of compounding. These include stronger cross-heads and piston rods, larger bearing surface on cross-heads, wider guides and better frames.

(3) Improvements in assignment consist in the use of compounds on through trains where there is little switching to do, their use on level roads where there is little occasion to drift, and their assignment to high-speed passenger trains because of their ability to work regularly and easily in such service and to pick up readily the time lost on account of detentions.

28. In general terms, what would you designate as the weak or defective points or those most in need of perfecting at present time on compound locomotives?

There is a need of improvement in the intercepting valve and a change in design, so that the same pressure will be exerted by both pistons; the necessity of reducing the back pressure at high speeds is also apparent. Frames seem too weak, and where the single-rail frame is used there is difficulty in holding the cylinder and frame together. The cross-head, piston and valve-rod packing and relief valves all show the need of proper attention and consequent improvement.

29. Have you converted any compounds to simple engines and was the change made necessary by general undesirability of the compound feature or by special local conditions, and if the latter, give in a general way the conditions justifying the change?

Ten roads indicate that they have not changed any compounds to simple engines. On four roads changes were made as follows:

One changed because of local conditions.

One because of failure of cylinder and weakness of frame.

One because the cylinder needed heavy repairs and the compounding features were not modern.

Twenty-six freight and four passenger engines were changed because of trouble they gave with broken pins, piston rods, cylinders, frames, axles, etc. These failures were the outgrowth of physical conditions of the road which imposed hard service upon the engines and their consequent failure through poor designs.

Definite and accurate data as to the saving effected by compounding and the cost of repairs was rather difficult to obtain, which is to be regretted, as it would undoubtedly aid in deciding the minimum cost of coal with which it would be economical to use the compound. However, such data as could be obtained relative to the above points are here presented in tabulated form. In the cases cited, comparison was made between engines of similar size and type and engaged in the same service, as far as possible, differing only in the matter of compounding.

Name of Road.	Cost of Repairs per Engine Mile.		Per Cent Saved in Fuel Due to Compounding.
	Compound.	Simple.	
C. & L. R. R.	.0609	.0537	25.00
C. B. & Q. R. R..............	.0168	.0125	16.69
Erie R. R....................	.0407	.0294	.....
M. St. P. & S. Ste. M..........	.0601	.0729	9.60
N. P. R. R....................	.0179	.0209	20.00
	.0393	.0379	17.62
	IN PASSENGER SERVICE.		
C. B. & Q. R. R..............	.0241	.0199	13.80

From an inspection of the figures here given it would seem that in the matter of repairs the advantage is with the simple engine, while the compounds without exception have the advantage in fuel economy.

The data obtained is quite too meager to permit drawing any definite conclusion as to what average result might be expected from the compound under any given set of conditions.

In order that the report may be of value for reference purposes on this subject, a number of letters from roads that have given the question careful attention and the records of such tests as have come to hand will form part of the report. (See Appendix II.)

Conclusions.

In view of the data here presented and the expressed opinions in the answers to the circular of inquiry, the committee believes the following conclusions are justified.

1. (*The conclusion of the committee that the compound locomotive was emerging from the experimental stage was held by the convention to be erroneous and not in accordance with the facts. Conclusion No. 1 was, therefore, ordered cut out.*)

2. Compounds have been in use in freight service longer than passenger service and there are more in such service; but in recent years there seems to be a disposition to use them also for fast, heavy passenger service. The compound is not as well adapted to switching service as the simple engine.

3. The ton-mile system forms the basis of comparison between compound and simple locomotives. The average saving of the compound in coal consumption is 16.5 per cent.

4. The actual saving of the compound depends upon the price of coal. The greatest economy will be attained where the compound is worked continuously well up to its limit. The opportunity for saving is greater in freight service than in passenger.

5. The compound is not so flexible an engine as the simple.

6. There should be no difference in the size of drivers between the compound and simple engine in the same service.

7. The compound may be successfully pooled, if such practice is followed, with simple engines.

8. The rating for compounds should be no higher than simple engines of the same class, weight and steam pressure.

9. If it be desired to work the engine simple over maximum grades, the rating may be slightly higher for the compound than for the simple engine.

10. The correct ratio of cylinders is difficult to determine, as other factors than the determination of such ratio as will secure the minimum cylinder condensation enter into the question. In the two-cylinder type it is of paramount importance that the work in both cylinders be equalized as closely as possible for all positions of the reverse lever. This is easier accomplished if the ratio be kept down, and in freight engines it seems that a ratio of about 2 1-3 to 1 would be acceptable, while for passenger a slightly higher ratio, 2.37 to 1, might be used.

For the four-cylinder compound the most important question is that of equalizing the pressure on the high and low pressure pistons, and a ratio of 3 to 1 gives good results.

11. Manual control of compounding feature is preferable to the automatic.

12. There is no necessity for having any trouble due to the use of a large cylinder if proper care be used in the design of the piston.

12½. There is less danger of setting out fires from the stack of the compound than of simple engines.

13. It is necessary to relieve the cylinders while drifting, large relief valves being used on four-cylinder compounds and the by-pass on two-cylinder compounds.

14. The piston valve is preferable to the slide valve, as more perfect balance is secured, and consequently less wear of valve and seat and less strain on valve motion.

15. When comparisons have been made between compound and simple engines, the pressures were usually the same.

16. In starting it is necessary to work the engine simple; that it is bad practice to so rate the engine that it will be necessary to work it simple over heavy grades.

17. Engineers are apt to abuse the privilege of working the engine simple. With the same supplies at hand for the repairs on compound

engines, there is no necessity for the compound remaining out of service for repairs any longer than the simple engines.

19. The cost of boiler repairs is less on the compound and may average 19.6 per cent less than for the simple engine.

20. The cost of maintaining the machinery on the compound is a little more than on the simple.

21. The cost of lubrication on the compound will be about fifteen per cent more than on the simple engine.

22. The compound will be an economical machine whatever the price of fuel.

23. More compounds are in use where the fuel is expensive than where it is cheap.

23½. There is no necessity for any difference in the size of the exhaust nozzle of the compound and that of the simple.

24. Many and careful comparisons have been made of the relative performance of the compound and simple engine, and the position of the compound in railroad economy may now be determined.

25. It is possible to build a compound that will give satisfaction equal in tractive power to any of the simple engines.

26. The low-pressure piston will give better results if made of cast steel with a bronze bearing ring cast in its periphery.

27. The most notable improvements have been in the intercepting valve, in steam distribution and better design of the machinery.

28. Attention is called to the necessity of further improvement in design of machinery, intercepting valve and steam distribution.

29. With the modern machines the compound holds its place as against the simple and it is not advisable to change any in use into simple engines.

In the preparation of the report free use was made of all available material, and the authority is generally given in the text.

Several points have been taken from Wood's "Compound Locomotives" and from Thurston's "Manual of the Steam Engines." The periodical literature supplied its quota as well as the Western Railway Club Library and constituted a valuable aid in the work.

Respectfully submitted,
J. F. DEEMS,
A. E. MITCHELL,
JOHN PLAYER,
J. E. SAGUE,
J. H. SETCHEL,
Committee.

WEST BURLINGTON, IOWA, May 14, 1900.

APPENDIX I.

As the operation of the starting mechanism is one of the vital points in connection with compound locomotives, such illustrations and descriptive matter as could be secured from the prominent builders of locomotives are presented for the consideration of any who may be interested in the subject.

BALDWIN-VAUCLAIN COMPOUND.

The distinguishing features of this engine are in the arrangement of the cylinders and the valve which effects the steam distribution as shown in Fig. 1. The following description of the valve and the operation of the engine is given in the little book descriptive of the Vauclain Compound, issued by the Baldwin Locomotive Works:

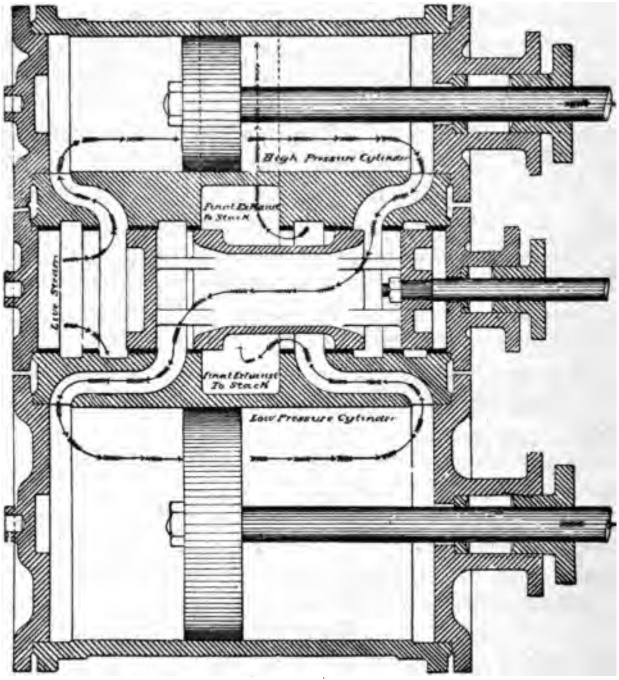


FIG. 1.—Baldwin-Vauclain Compound Cylinders.

"The valve employed to distribute steam to the cylinders is of the piston type, working in a cylindrical steam chest located in the saddle of the cylinder casting, between the cylinders and the smoke box, and as close to the cylinders as convenience will permit. This valve is double and hollow and controls the steam distribution of both cylinders. The exhaust steam from the high-pressure cylinder becomes the supply steam for the low-pressure cylinder. As the supply steam for the high-pressure cylinder enters the steam chest at both ends, the valve is in perfect balance except the slight variation caused by the area of the valve stem at the back end.

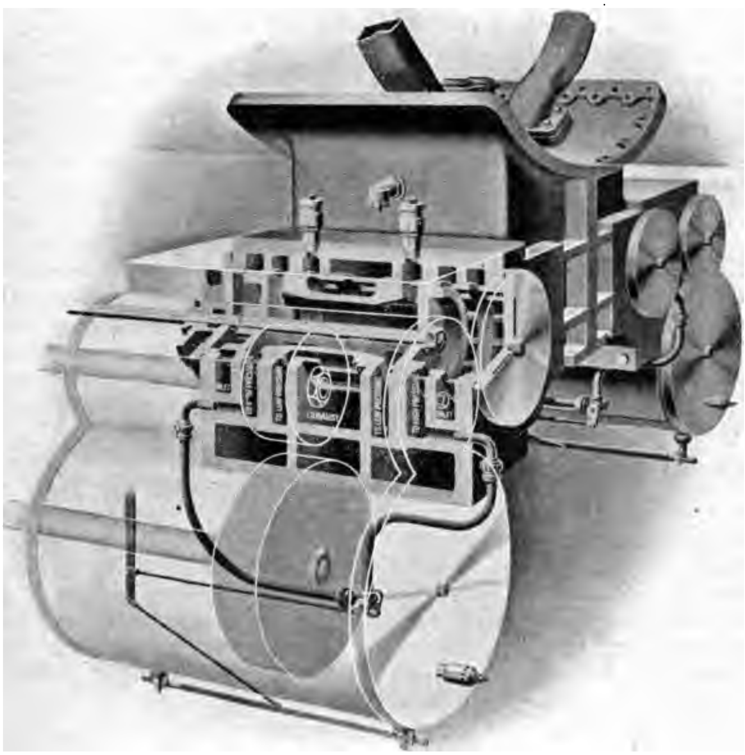


FIG. 2.—Baldwin. Attachment of Starting Valve.

"It is obvious that in starting these locomotives, with full trains, from a state of rest, it is necessary to admit steam to the low-pressure cylinder as well as to the high-pressure cylinder, which is accomplished by the use of a starting valve as shown in Fig. 2. This is merely a by-pass valve which is opened to admit steam to pass from one end of the high-pressure cylinder to the other, and thence through the exhaust to the low-pressure cylinder, and is operated by the same lever that operates the ordinary cylinder cocks, thus making a simple and efficient device, and one that need not become disarranged."

THE BALDWIN TWO-CYLINDER COMPOUND.

The features which distinguish the Baldwin Two-Cylinder Compound from others are found in the intercepting and reducing valves shown in Fig. 3 and Fig. 4, and their location in Fig. 5. Concerning these valves, the Baldwin Locomotive Works says in its Record of Recent Construction:

"In designing this type of compound locomotive the essential feature sought was to provide an intercepting and reducing mechanism which would permit the engine to work as a single-expansion engine until such time as the engineer desired to change it into a compound. To obtain this result, the normal condition of the parts employed is such that the engine will start at any point of the stroke and any position of the cranks. To accomplish this result an intercepting valve A is employed, consisting of two pistons connected by a distance bar or rod; also a reducing valve C, both of which are placed in the saddle casting of the high-pressure cylinder. The function of the intercepting valve A is to divert the exhaust steam from the high-pressure cylinder either into the atmosphere when working single-expansion, or into the receiver when working compound, and is operated at will by the engineer.

"The function of the reducing valve is to admit live steam at reduced pressure into the receiver when engine is working single-expansion, and also to close itself instantly when the intercepting valve is changed to the position which causes the engine to work compound, it being evident that the receiver needs no live steam from the boiler when receiving its supply from the exhaust of the high-pressure cylinder. A further function of the reducing valve is to regulate the pressure in the receiver so that the total pressure upon the pistons of the two cylinders will be equalized. The intercepting and reducing valves are both cylindrical in form, placed in bushings in which suitable ports are cut. The movement of the valves A and C in one direction is caused by steam pressure against the action of suitable coil springs. These springs cause a return movement when the steam pressure is withdrawn. These valves are controlled by steam supplied through pipes D from the operating valve in the cab.

"The reducing valve C is operated automatically by the pressure in the receiver when not closed permanently by the steam in the operating pipe D. For this purpose the port E is provided, connecting the receiver with the large end of the reducing valve piston, under the poppet valve F, which remains open as long as the engine is working compound, the poppet valve G being closed by the same pressure, thus preventing its escape to the atmosphere. This pressure, acting on the large end of the reducing valve, causes it to close the steam passage H between the live steam passage of

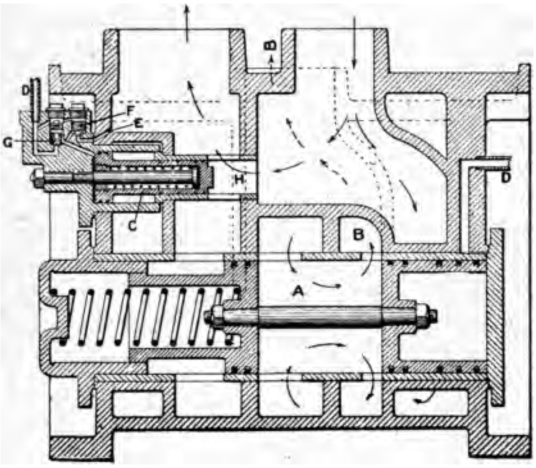


FIG. 3.—Baldwin. Intercepting Valve for Two-cylinder Compound, Running Simple.

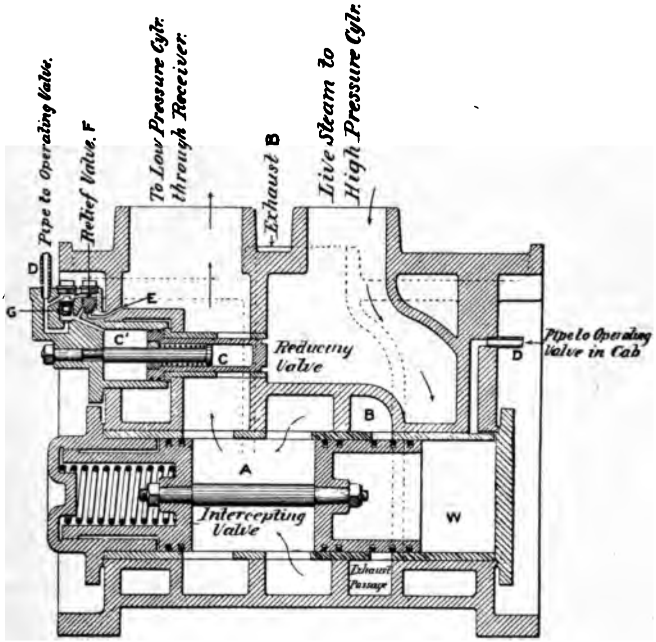


FIG. 4.—Baldwin. Intercepting Valve for Two-cylinder Compound, Running Compound.

the high-pressure cylinder and the receiver when the receiver pressure becomes excessive, and vice versa when deficient, the two ends of the reducing valve being so proportioned that equal cylinder power will be given to both sides of the engine. When the engine is in its normal condition, the lever of the small operating valve in the cab is placed at position marked "Simple," and the engine is then in position to work as a single-expansion engine, the steam pressure against the intercepting valve and the large end of the reducing valve being relieved, permitting the valves to assume (by the action of springs) the positions shown in Fig. 3. The ports of the intercepting valve A stand open to receive the exhaust steam from the high-pressure cylinder and deliver it to the auxiliary exhaust passage B, and through it to the atmosphere. At the same time the reducing valve is wide open, connecting the live steam passage H with the receiver, through

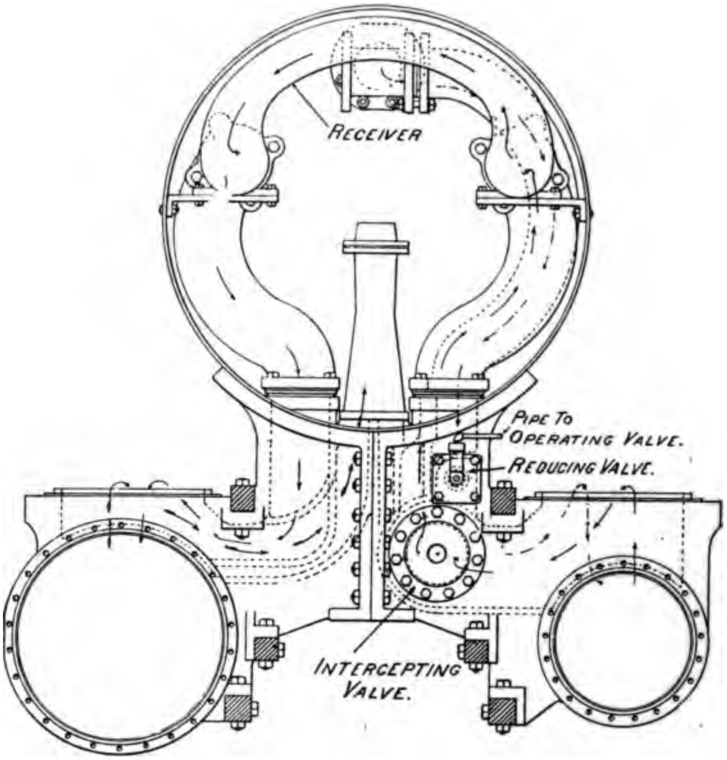


Fig. 5.—Baldwin. Location of Intercepting Valves.

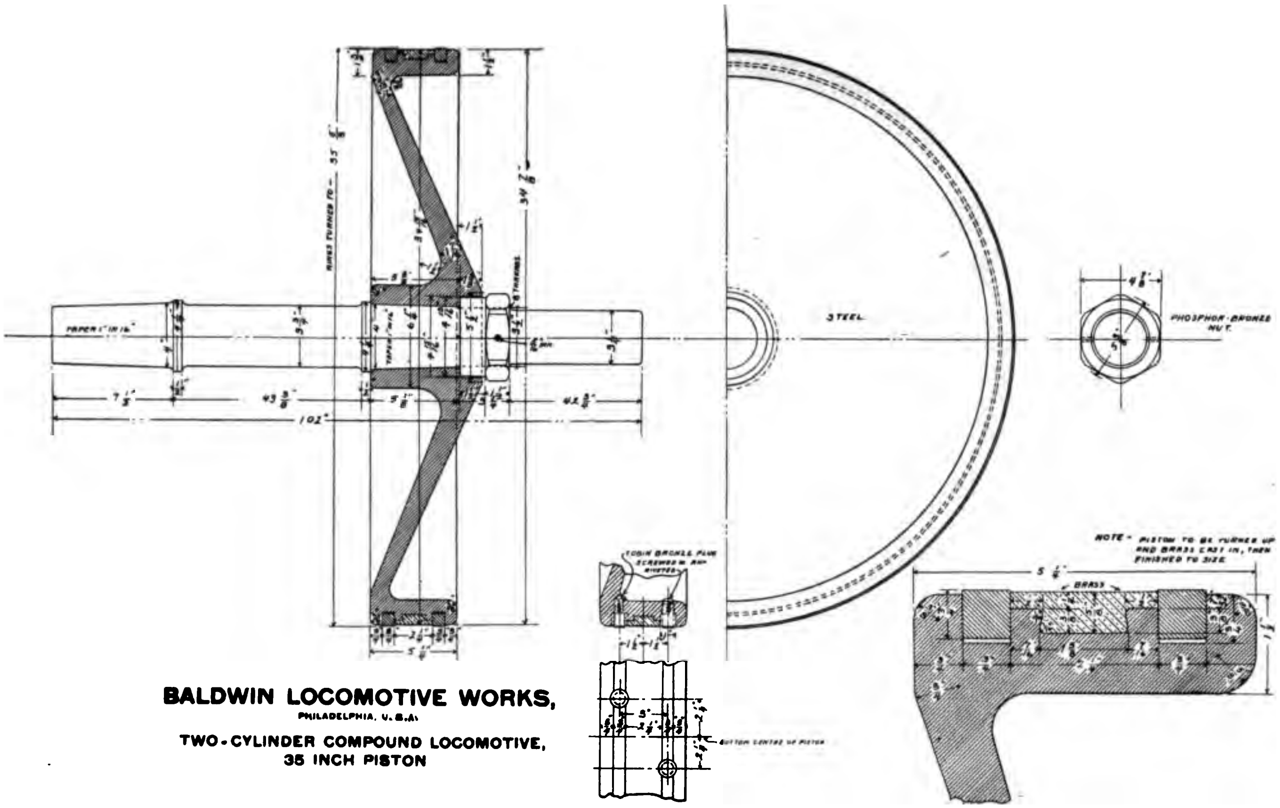

BALDWIN LOCOMOTIVE WORKS,
PHILADELPHIA, U.S.A.
TWO-CYLINDER COMPOUND LOCOMOTIVE,
35 INCH PISTON
STEEL
PHOSPHOR-BRONZE NUT.
NOTE - PISTON TO BE TURNED UP AND BRASS CAST IN, THEN FINISHED TO SIZE
BRASS
RINGS TURNED TO — 35 5/8
TAPER 1" IN 16"
6 THREADS
102"
BOTTOM CENTRE OF PISTON
FOUR BRONZE PLUGS SCREWED IN AND RIVETED

Fig. 6.—Low-pressure Piston.

which live steam enters and charges the receiver from which the low-pressure cylinder derives its supply. The receiver pressure is governed by the automatic action of the reducing valve previously explained.

"Thus the engine can be used as a single-expansion engine to make up trains and start them, and at the will of the engineer. The operating valve in the cab can be moved to position marked "Compound," which will admit steam to the supply pipes D, thence to the cylinder W and the cylinder C, changing the intercepting and the reducing valves instantly and noiselessly to position as shown in Fig. 4, diverting the exhaust from the high-pressure cylinder to the receiver, instead of to the atmosphere, and closing the passage H between the live steam passage and the receiver at the reducing valve. All parts liable to wear are made of piston type, depending on packing rings instead of ground joints for the prevention of leakage, and at the same time prevent the hammering action so common with the valves of the poppet type automatically arranged."

THE BROOKS COMPOUND.

The four-cylinder compounds are the Player patent tandem compounds, in which the low-pressure cylinders and steam chests are attached to the smoke box in the usual place and manner, and the high-pressure cylinders and steam chests are attached preferably to the forward end of the low-pressure cylinders, and having steam chests communicating with the steam chests of the low-pressure cylinders. The steam is supplied to the high-pressure valve chests through suitable connecting pipe, and the low-pressure cylinder exhausts through the saddle in the usual way. The high-pressure steam chests are fitted with hollow piston valves having internal admission, the low-pressure steam chests being also fitted with internal admission piston valves as shown in Fig. 7.

One of the chief advantages of this type of compound is that the castings for the tandem compound cylinders are and can always be made absolutely interchangeable with those of a simple engine, this arrangement necessitating no change whatsoever back of the cross-head and valve-rod keys or in the steam and exhaust pipes in the smoke box, the compound cylinders thus giving no more cost for application than would be the case in applying a pair of new cylinders to a simple engine.

The high-pressure cylinder is generally located ahead of the low pressure. This, however, is not necessary, and in some types of locomotives having four-wheeled trucks, it is preferable to place the high-pressure cylinder back of the low pressure, thus materially reducing the weight and rendering the parts more accessible. The pistons of the high and low pressure cylinders are arranged upon the same rod, and the intermediate head between the high and low pressure cylinders is fitted with suitable metallic packing. The low-pressure steam chest is provided with a reducing and starting valve connecting with the high pressure steam pipe shown in Fig. 8. This valve is permitted to operate automatically when the

necessary, admits sufficient steam to the low-pressure cylinder to give the locomotive its maximum power, the use of a separate exhaust valve, whereby the engine can be worked simple for long periods, has been found in practice unnecessary, the arrangement of admission and pressure-regulating valve previously referred to automatically performing all the requirements of the simple locomotive.

The valve operates as follows: Live steam operates upon the high-pressure piston in the usual manner; at the same time, steam is admitted to the high-pressure end of the pressure-regulating valve through the connecting pipe, causing the valve to open, passing thence through the hollow portion of the valve, causing the intercepting valve to automatically close against its seat. This steam flows through the passages of the intercepting valve into the low pressure end of the receiver, and acting upon the large end of the pressure-regulating valve, causes it to partly close as soon as the requisite pressure is obtained, and thereafter regulates the amount of steam admitted by the pressure-regulating valve maintaining an even pressure in the receiver. The reduced-pressure steam thus admitted to the receiver acts upon the low-pressure piston in the usual manner. As soon, however, as the high-pressure cylinder has exhausted sufficient steam into the high-pressure end of the receiver to overbalance the intercepting valve, this valve opens automatically, at the same time locking the pressure-regulating valve on its seat. The exhaust steam from the high-pressure cylinder then flows through the receiver and acts directly upon the low-pressure piston, the pressure of this exhaust steam, even when considerably reduced, being sufficient to keep the pressure-regulating valve closed through the action of the combined valves at all times.

The piston used in the low-pressure cylinder is shown in Fig. 10.

COOK COMPOUND.

This compound is of the two-cylinder receiver type, with optional starting gear.

The location and construction of the intercepting valve is shown in Figs. 11, 12 and 13. The operation of this valve is as follows:

To run the engine *simple* in starting, or whenever necessary to develop maximum power, pull handle to back position, admitting steam to the outer ends of intercepting valve cylinders. This closes communication between receiver and low pressure cylinder, diverts high-pressure exhaust to stack, and opens admission valve D, which admits live steam at a reduced pressure to low-pressure steam chest.

To run engine compound, place handle in forward position, admitting steam to inner ends of intercepting valve cylinders; this opens communication between receiver and low-pressure cylinder, closes passages between receiver and exhaust to stack and closes admission valve D. After changing from simple to compound or vice versa, handle should be placed in mid-position, cutting off steam from intercepting-valve cylinders.

The position of the intercepting valve under different conditions is shown in Fig. 14. When the engine is running compound, its position is as shown in (1), and when running simple in (2). When the change is made from simple to compound, the exhaust passages A A are shut off from the receiver before the valve leaves the bridge B as shown in (3).

THE RICHMOND COMPOUND.

The Richmond engine is one of the cross-compound type, having a high-pressure cylinder on one side and a low-pressure cylinder on the other, an intervening receiver, and an intercepting valve in the cylinder saddle, through which the engine is converted from compound to simple, and vice versa. The cylinder ratio is usually about 2.5 to 1.

There are three special valves — an intercepting valve which controls the connection between the high-pressure exhaust and the low-pressure steam supply, a reducing valve which at proper times admits live steam to the low-pressure chest and regulates the pressure in the low-pressure cylinder, and an emergency valve which, when the engine is to be worked single expansion, opens connection between the high-pressure exhaust and the atmosphere.

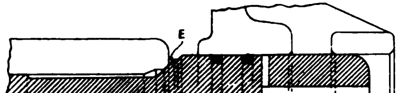
Steam from the dry pipe passes directly to the high-pressure steam chest and also to the cavity surrounding the reducing valve. The exhaust from the high-pressure cylinder goes to the opening surrounding the intercepting valve and can flow thence either to the low-pressure steam chest or directly to the stack, as the position of the valve determines. The position of the intercepting valve when the engine is working simple is shown in Fig. 15; where the engine is working compound its position is as shown in Fig. 16.

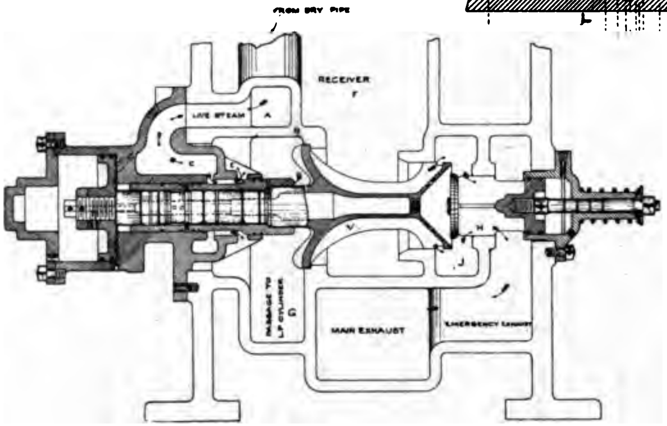
The operation of the valves is described as follows: The high-pressure cylinder exhausts into a receiver which is placed inside the smoke box and opens into chamber F. The intercepting valve as shown at V has a piston on its outer end, which acts as an air dash-pot, preventing any slamming of the valve. Around the stem of this valve is a sleeve L which has an axial movement on the stem, and acts as an admission and reducing valve to the low-pressure steam chest when starting and when working simple. Valve H is a plain, bevel-seated, winged valve, and is called the emergency valve, as by its use the engineer can, at will, operate as a simple engine.

When starting, steam from the boiler goes to the high-pressure cylinder in the ordinary way, and also to the port C through a three-inch steam pipe connected to the dry pipe. When the throttle is opened, no matter in what position the valve stands, there is no pressure in the receiver F, and the pressure on the shoulder E on the sleeve L moves the sleeve and the valve V to the right, closing the receiver and letting steam past the shoulder E into the low-pressure steam chest G.

Now, since the area of the end B of the sleeve L is twice that of the shoulder E, half of the boiler pressure will move the sleeve L to the left, CARD-7716

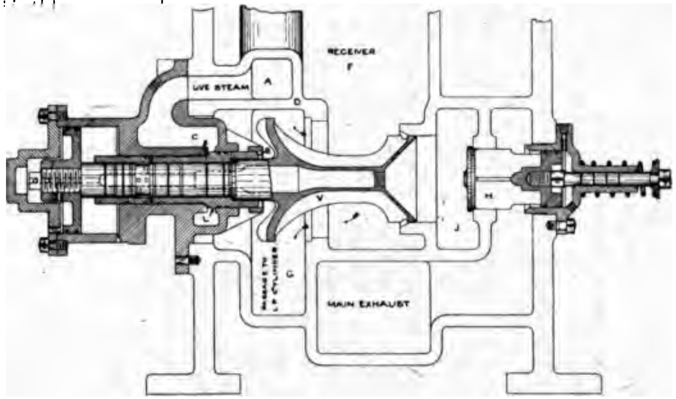
AUTOMATIC STARTING VALVE
THE RICHMOND LOCOMOTIVE WKS SYSTEM OF COMPOUNDING LOCOMOTIVES
RICHMOND VA USA SEPTEMBER 24, 1898.





POSITION WORKING AS SIMPLE ENGINE.

FIG. 15.—Richmond. Starting Valve, Engine Working Simple.



POSITION WORKING AS COMPOUND

FIG. 16.—Richmond. Starting Valve, Engine Working Compound.

cutting off steam through port C and thus equalizing the work in both cylinders, since the reduced pressure is thus maintained in the low-pressure steam chest by the reciprocating action of the sleeve. After, say one and one-half revolutions, the pressure accumulates in the receiver F, due to the exhaust from the high-pressure cylinder, and acting against the large face of the valve V moves this valve to the left, carrying the sleeve with it, thus opening a straight connection between the high-pressure exhaust and the low-pressure steam chest, and at the same time permanently cutting off live steam from the port C.

In starting on grades or when exerting maximum power, the engineer can move the three-way cock in the cab, letting boiler steam on the emergency valve H and holding it open against its spring. This exhausts the small cavity J in which the pressure is equalized with the receiver through holes in the rear end of the valve V, and then the valve, being unbalanced, moves with the sleeve L instantly to the right, assisted by the steam pressure on the shoulder E of the sleeve. The high-pressure cylinder has now a separate exhaust around the end of valve V, through valve H, into the main exhaust, since the intercepting valve remains closed, due to no accumulated pressure in the receiver F. The low-pressure steam chest then gets reduced-pressure steam direct from the boiler through port C and reducing valve L.

Except when working simple, the valves work automatically. The lubricator to the low-pressure cylinder enters port A and thus insures constant lubrication to the intercepting and reducing valves.

Owing to the small area of port C and the contracted exhaust through valve H, the engines develop less power as a simple engine than as a compound at a speed at over eight or ten miles per hour, and thus the runner is compelled to work compound. Should either side break down, the emergency valve can be opened and the engine brought in on one side like an ordinary simple engine. The equal division of the power of the locomotive between the two cylinders at varying speed and loads are effected by giving the low-pressure valve amounts of lead and lap differing from those of the high-pressure valve. Thus each cylinder has a point of cut-off differing from that of the other for the same position of the links, the latter being of the usual type.

The intercepting valve is automatic, responds positively to variations of pressure and allows the engine to start without jerking, regardless of reverse lever or crank or positions. The engine is also convertible into the single-expansion type whenever the engineer may deem this necessary for extraordinary pulling on hills and curves where flange friction aids adhesion, and an increase of from twenty-five to thirty per cent in tractive power is thus obtained at low speeds. It is the only system that is provided with overpass valves to avoid air compression in the cylinders, also thumping, and to reduce the air jet when steam is shut off while running down grade. The engineer has nothing more to attend to on the compound engine of this type than on a simple engine, except in an emergency, when he will be very glad to turn the handle of a cock that he may get over a hill when he is about to stall.

(Taken from *Cassier's Magazine.*)

The application of the exhaust relief valve is shown in Fig. 17.
The bearing for extended piston rod is shown in Fig. 18.
The piston used in low-pressure cylinders is shown in Fig. 19.
The piston used in high-pressure cylinder is shown in Fig. 19*a*.

SCHENECTADY COMPOUND.

This compound is of two-cylinder receiver type having manual control. The steam passages are as shown in Fig. 20. The action of the valves connected with the compounding feature of the engine is as follows:

Assuming the engine to be at rest. To start simple, the handle of the three-way cock is thrown by the engineer so as to admit pressure through the pipe D against the piston (A) forcing it and the valves B and C to the position shown in Fig. 21. As the throttle is opened, steam passes directly from the boiler into the passage E, forcing the intercepting valve into the position shown in Fig. 22. Thence the steam goes through the intercepting valve by the ports (K) (K) and the passage (G) (G), thence to the low-pressure steam chest; at the same time steam goes from the boiler through the steam-pipe to the high-pressure steam chest. The exhaust from the high-pressure cylinder goes directly to the atmosphere through the receiver passages (H), thence through separate exhaust valve (B) to the stack. Steam from the low pressure piston is exhausted in the usual way. The object of the reducing valve (L) is to prevent steam at the boiler pressure from being admitted to the low-pressure cylinder. In going through the reducing valve (L), the pressure of the steam is reduced so that it has the same ratio to the boiler pressure as the diameter of the high-pressure cylinder has to the diameter of the low-pressure cylinder.

Having started simple, to change to compound the handle of the three-way cock in the cab is turned so that pressure is taken from the piston (A), when the spring (I) will throw the piston valves to the right, thus closing the separate exhaust. The pressure in the receiver will then rise and force the intercepting valve to the left to the position shown in Fig. 21, opening the passage for the exhaust steam from high-pressure cylinder through the receiver to the low-pressure steam chest. This movement of the intercepting valve to the left also closes the passage (G) (G), shutting off the admission of boiler steam to the low-pressure steam chest.

To start the engine compound, the separate exhaust valve is left closed as in Fig. 22. As the throttle is opened, the pressure of steam through the passage (E) will force the intercepting valve to the right, to a closed position, at the same time boiler steam will be admitted to the low-pressure steam chest through the ports (K) (K) and passages (G) (G). The high-pressure cylinder will exhaust into the receiver until the pressure is sufficient to force the intercepting valve to the left, as shown in Fig. 2, when the engine will work compound.

Directions for disconnecting on the road: In case of any failure of the time on the road so that it becomes necessary to disconnect one side and run in with one side alone, the following may be of assistance to the engineer. Should it become necessary to disconnect the right side and run in with the left side, the valve in the right steam chest should be placed central

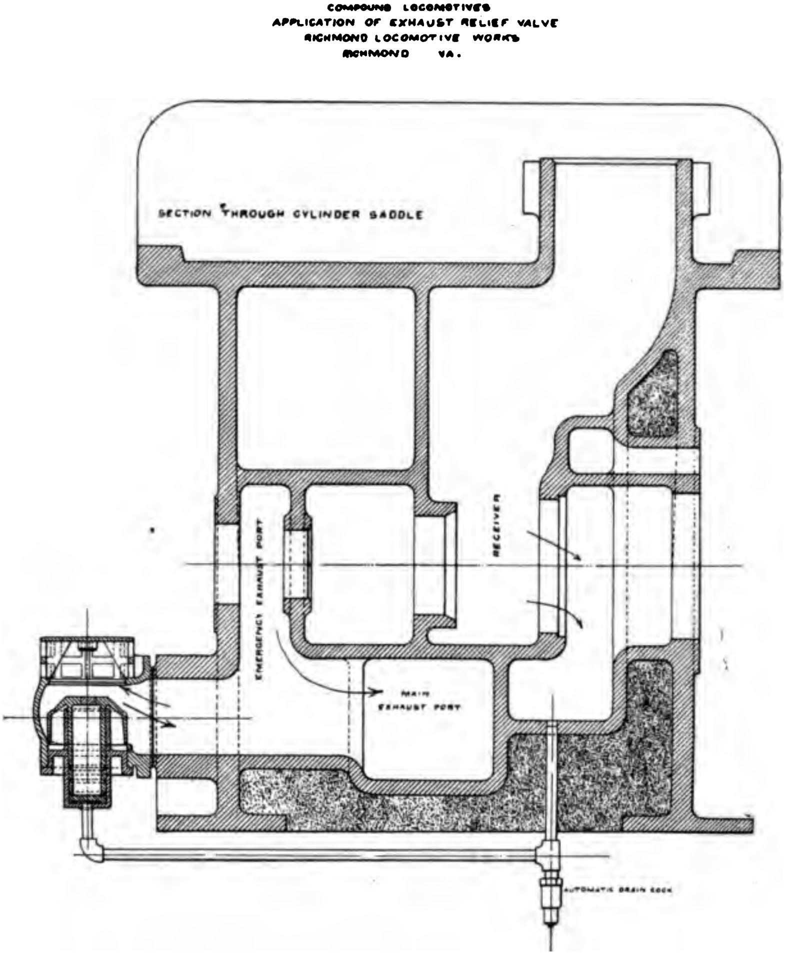


FIG. 17.—Richmond. Exhaust Relief Valve.

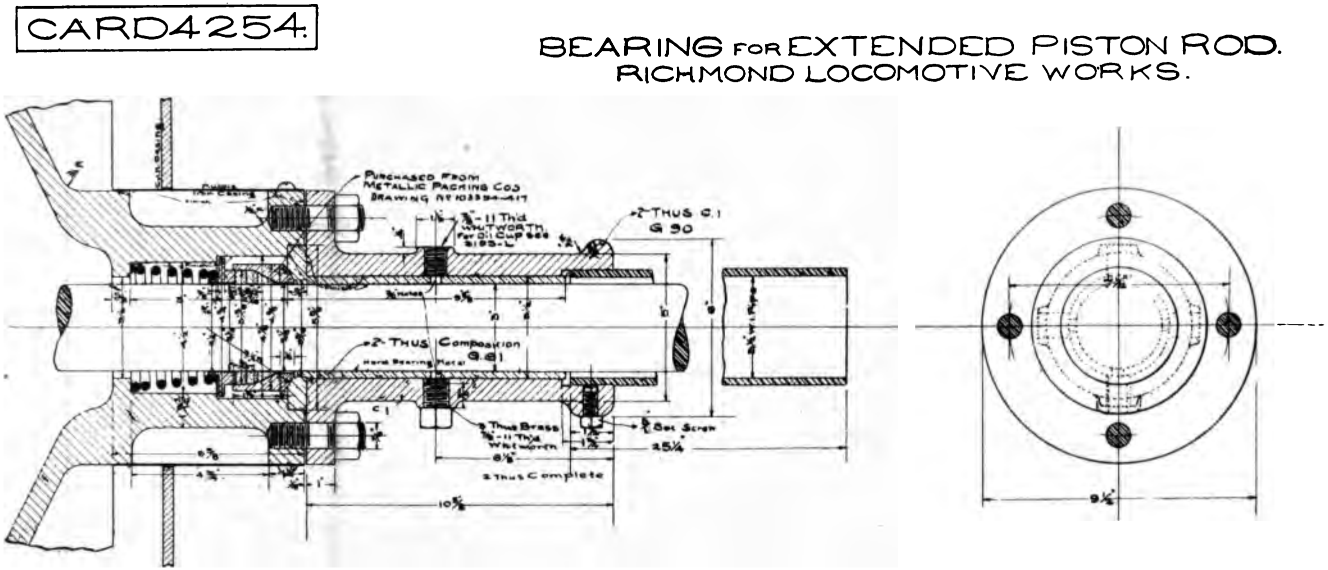

CARD 4254.
BEARING FOR EXTENDED PISTON ROD.
RICHMOND LOCOMOTIVE WORKS.
PURCHASED FROM METALLIC PACKING CO'S DRAWING Nº 103394-417
⅞"-11 Thd WHITWORTH For Oil Cup see 3195-L
1⅛
2-THUS C.I G 90
2-THUS Composition G.81
Hard Bearing Metal
C I
2 Thus Brass ⅞"-11 Thd Whitworth
⅝ Set Screw
25¼
8⅛"
2 Thus Complete
10⅝
6⅝
4⅜
1"
9½"

Fig. 18—Richmond. Bearing for Extended Piston Rod.

and blocked. Then the handle of the three-way cock in the cab should be turned so as to admit pressure against the piston (A) and left in this position, which will open the separate exhaust valve allowing the steam from the high-pressure cylinder to exhaust to the atmosphere.

Should it become necessary to disconnect the left side and run in with the right side, the valve in the left chest should be placed central and blocked. When the throttle is opened, the pressure of steam will close the intercepting valve and at the same time steam will be admitted directly from the boiler to the right steam chest.

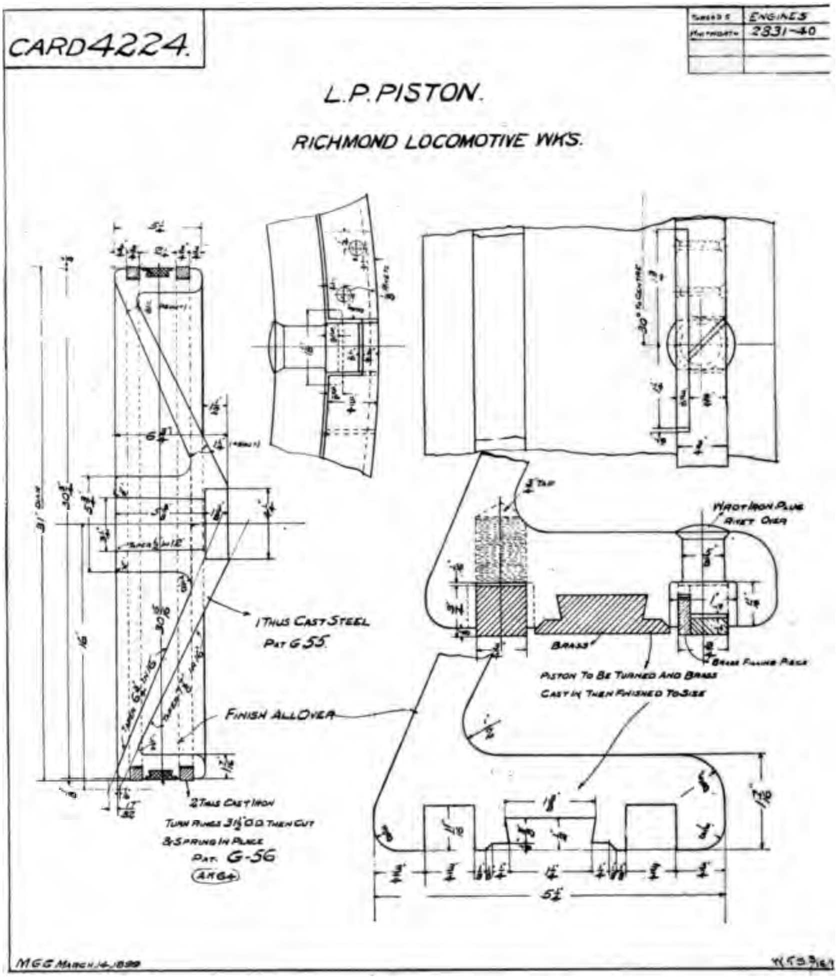


FIG. 19.—Richmond. Low-pressure Piston.

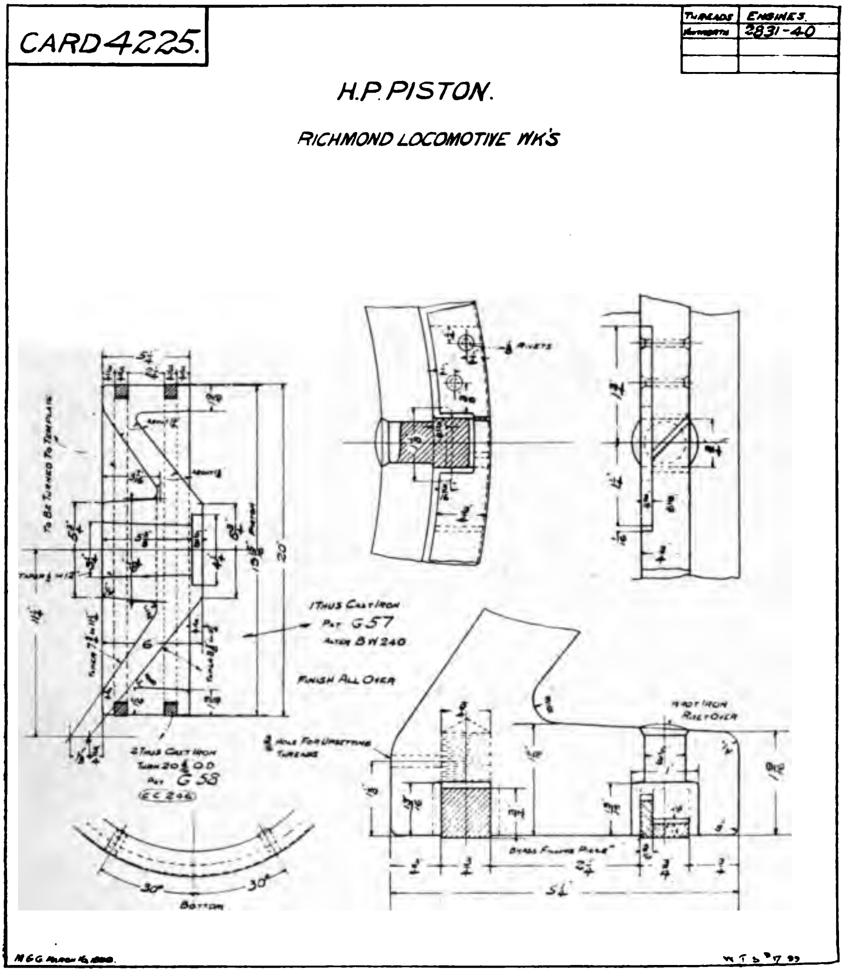


FIG. 19*a*.—Richmond. High-pressure Piston.

APPENDIX II.

The following are some of the more important letters that have been received from those roads which have given the question of compound locomotives some attention. As the answers to the questions asked in the "Circular of Inquiry" are the essential part, only that portion of the letters bearing upon those points will be given.

LETTER NO. 1.

1. We have at present time 140 compound locomotives in service as per attached list and 36 building. The list will show you the classes of the engines.

2. Our experience with compound locomotives commenced in July, 1893, with one Rhode Island, for which we purchased the cylinders. In December, 1893, we turned out one of the same build of engines with Vauclain cylinders on for the purpose of comparison. In October, 1896, we put a pair of Pittsburg compound cylinders on a ten-wheel engine of our own build, and in February, 1897, one pair of Richmond compound cylinders was put on a ten-wheel sister engine to the last of our own build. In June, 1897, we commenced to turn out new ten-wheel compound engines compounded on the Pittsburg system, and in September and October, 1897, received thirteen ten-wheel four-cylinder compound engines from the Baldwin Locomotive Works. We have not built any ten-wheel compound engines since July, 1898, and those working have 62-inch driving wheels. We commenced to put compound consolidations of the four-cylinder type on the road in March, 1898, and of the Richmond type in April, 1898, and of the Pittsburg type of our own build, in September, 1898. The ten-wheel engines have been running in both freight and passenger service. Some of the consolidation engines with 51-inch driving wheels, of which we hav thirty-five, are running in ordinary freight, but the balance of the consoli dations have 57-inch wheels and are running principally fast freight. W have no compound engines in switching service.

3. The actual fuel economy we find extremely difficult to ascertain, but it is very evident, and in one case where I took all the compounds on a division of which the main line was about 1,450 miles long, for four months in the winter, the engines in freight service showed an average saving of 17.2 per cent and the ten-wheel engines with 62-inch drivers in passenger service showed 8.9 per cent, but the economy, we find, fluctuates very greatly from month to month, showing the effect of different conditions. This estimate was on the ton-mile basis.

4. So far as our experience has gone in the past, compound engines have shown the greatest fuel economy in freight service, but it may be that

the size of the driving wheels or the proportions of the cylinders militated against the performance in passenger service, or there may be other conditions interfering. With regard to the character of the road, compound engines are at the greatest advantage when the section over which they are running has a few points at which the ruling grades are exceptionally stiff for a short distance and too long to be got over by taking a run up it, and they maintain their superiority if the cylinders are proportioned to suit where the grades are continuous or heavy.

5. We see no reason at present why compound engines should not be as readily adapted to various kinds of service as simple engines. We have not done as much work in passenger service as in freight, but there seems to be no reason why they should not give good satisfaction.

6. We have not changed the size of the driving wheels on account of the engines being made compounds, but there is a general tendency to increase the size of driving wheels of consolidation engines both for simple and compound.

7. Some of these compound engines, especially the ten-wheel engines, have been on parts of the road where pooling has been practiced, but it is poor practice until the men have been educated one by one to handle them properly, and if this is done there seems to be no reason why pooling will not work to the same effect with compound engines as simple.

8, 9. If the rating of an engine in compound is the same as a sister engine in simple form, then the compound engine can be depended upon on sections where the grades are not very long, but too long to run over, to take up about seven per cent more train. In doing this, the engine should be worked simple form only when the speed gets down to about five or six miles per hour, and for as short a distance as possible, to give the train a little impetus, say to bring the speed up to about eight miles per hour, and then should be worked in compound until the speed falls down again, and so on. In this way the economy will be largely maintained. I have not yet seen any compound engines which would steam well and continuously in simple form with the class of coal that is used on this road. This does not apply to engines with Wootten fire boxes.

10. A ratio of cylinders for freight service appears to work well at 2½ to 1, and up to the present I can see no definite reason to change except that there is considerable water formed in the low-pressure cylinder as a rule, which seems to indicate that the ratio is rather large. For passenger service we have not yet carried out investigations close enough to ascertain, but am of opinion that about 2⅛ or 2¼ to 1 will be found most economical.

11. This question may be construed differently. If the change from simple to compound is automatic and not controlled by the engineer, then the benefit to be derived from working the engine in simple form for short distances is lost. If it is construed to refer to such devices as to start simple and move into compound automatically when so set by the engineer, and can be at any time prevented from moving into compound or changed from compound to simple while working by mechanical means, there is not

much difference whether the movement is made automatically or by mechanical devices, but in the latter case there is less opportunity for the device to get out of order. If it works automatically any disorder in its operation is liable to produce loss and cause trouble to find the cause. If the change is made mechanically, such trouble is readily discerned. It is essential that the engineer shall be able to change the engine from compound to simple at will while working.

12. I am not prepared to say that we can trace any trouble to this source.

12½. There is unquestionably very much less danger of starting fires from the stacks of compounds than from simple engines. I have personally seen cases where the amount of cinders thrown out was decreased about 90 per cent, and the temperature of the sparks appears also to be much lower on the average. The compound engines appear to be giving excellent satisfaction generally in this respect.

13. The latest practice to relieve the cylinders when drifting down hills in addition to the large relief valves is to notch the reversing lever up or to use a little steam.

14. We have used both slide and piston valves, and up to the present the slide valves have given the least trouble. This, however, may be because the piston valves are operated by a valve-rod which is not in the center of the valve. We have had some cases of broken eccentric rods which we have been totally unable to explain, and in all cases it has been in engines of this type.

15. In comparing compound and simple engines, the compounds have usually, but not always, carried 200 pounds pressure and the simple engines 180 pounds. Whenever we have made tests we always have had them carry the same boiler pressure.

16, 17. The compound engines are worked simple to some extent by engineers until they have time to learn to operate them properly, and they have been very much abused in this way, but as the more intelligent men become accustomed to them they prefer to take a compound engine rather than a simple one.

18. Two-cylinder compound engines built within three or four years are not out of service for repairs any more than simple engines. With four-cylinder compound engines we have had some trouble with cross-heads, piston rods and metallic packing, but which we expect to overcome shortly.

19. We have not yet found evidence to show that there is any difference in cost of maintenance of boiler for compounds than simple engines. Whatever difference there may be appears to be too small to notice in comparison with the total amount of work entailed by bad water.

20. The cost of maintenance to machinery to the two-cylinder compounds does not appear to be any more than the simple engines, and the same with four-cylinder compound engines, less the trouble above mentioned with cross-heads, etc.

21. There does not appear to be any difference in general figures.

22. With modern design of compound engines there should be no increased cost of maintenance to offset the gain in fuel consumption, but it takes some time to educate shopmen in the handling of repairs, as it does engineers in the handling of the engine.

23. The average cost of coal per ton is about $2.70.

23½. There does not appear to be any difference between size of exhaust nozzles on compounds and simple engines of the same power.

24. We have made a number of dynamometer tests but have not the results in form for publication.

25. We have not yet attained such a size of engines as to entail any difference about making corresponding size of compound engine.

26. The best material for low-pressure pistons is cast steel with cast-iron rings on the outside. The ring to be put on in such a manner that it can be replaced as the cylinder is bored out.

29. We have not converted any compounds to simple engines.

COMPOUND ENGINES.

WORKING.

TYPE.	PITTSBURG	VAUCLAIN.	RICHMOND	ROGERS.	RHODE ISLAND.	TOTAL.
Ten-wheel......	34	17	1	1	1	...
Consolidation ...	30	26	27	..	..	...
Atlantic........	..	3	..	..	..	...
	64	46	28	1	1	140

BUILDING.

Ten-wheel......	4	..	..	..	..	...
Consolidation ...	20	..	12	..	..	...
	88	46	40	1	1	176

LETTER NO. 2.

1. We have at present thirteen compounds in service. They are of the Atlantic four-cylinder type.

2. One year.

3. We have no data to give in fuel economy, except the comparison between two passenger engines of the same general dimensions, except that one is compound and the other is simple of the piston-valve type, extending over a period of four years. There is some economy in fuel in favor of the compound, as you will note by statement I enclose.

4. Compounds, in our opinion, would show greatest economy in continuous long runs. I would consider that they could be used to the best

advantage on roads of uniform grades, where there would be but little occasion to drift.

5. I do not consider the compounds as flexible as the simple engines. They are not well adapted for switching nor for local work.

6. We make no difference in size of driving wheels.

7. Compounds are pooled the same as other engines.

8. We make no difference in the size of train.

9. We do not work them simple over maximum grades.

10. ———

11. I prefer automatic.

12. Have experienced no trouble on this account, but this will be owing to the fact that our engines do very little drifting, being worked under steam continuously.

12½. There is much less tendency to throwing fire with compounds than with simple engines.

13. We have no occasion to, using steam continuously.

14. We use piston valves of external admission type; have found them to wear a good deal both in seats and rings.

15. Same steam pressure is carried.

16. Only to start.

17. Some engineers have a tendency to use high-pressure steam in starting for a longer period than is necessary.

18. In the comparison handed you, the compounds lost more trips than simple engines.

19. We have found but little difference in this respect, although there is some comparison in favor of the compound.

20. In this case the cost of repairs to machinery was slightly in favor of the compound.

21. No difference in cost of lubrication.

22. A compound engine improperly designed might use up in maintenance the slight advantage of fuel economy.

23. About $1.50 per ton.

23½. A slight difference in favor of the compounds in size of exhaust nozzles.

24. None.

25. I think there would be no difficulty in using a compound of equal capacity to that of a simple engine, if properly designed.

26. Would favor low-pressure pistons made of steel with an outer ring of bronze or cast iron.

27. Only noticeable improvement in the compounds has been the cylinder ratio and some improvement in the diameter of cylinders and frames.

28. The defective points still remaining about compounds are numerous, particularly weak frames and connections. Since the compound engines were introduced not many years ago, high-steam pressure has become the rule and engines are being made much larger, and while frames and cylinders have been enlarged and strengthened, the work has not kept

pace with the requirements. The design of compound engines, particularly the four-cylinder class, is of the single-rail frame, and it seems impossible to hold the cylinders and frame together. There seems to be objections to applying the double-rail on account of its coming in the way of the piston valves—in other words, blocking the space for their removal. Our experience has demonstrated that some such measures must be taken to give this type of engines the necessary strength.

29. We have converted but one compound freight engine to a simple engine, and this was practically brought about by failure of cylinders and general weakness of the frame.

LETTER NO. 3.

1. Fifty-three ten-wheel freight, thirteen Atlantic type passenger.

2. Eight years; in freight service, fifty-three from one to eight years; in passenger service, thirteen from one to five years.

3. Eighteen per cent economy in freight service. What data we have in passenger service indicate at least as much economy, but our performance sheets in the latter are not exactly comparative.

4. On low grades, with the locomotives working well up to their capacity.

5. No, they are not quite as flexible.

6. Yes, slightly larger driving wheels in both passenger and freight service.

7. We do not pool locomotives.

8. Compounds are not given increased rating, but we find the compound more reliable in getting its train over grades.

9. Yes.

10. About 2.80 to 1.

11. Manually, because of the greater advantages that it affords in starting and the less liability of getting out of order.

12. No.

12½. Yes, considerable.

13. Yes, relief valves directly connected to steam pipes and steam chests.

14. Piston valves, which we prefer.

15. No. Simple engines, 180 pounds; compound, 200 pounds pressure.

16. Less than five per cent.

17. No.

18. No, cost of repairs as compared with simple engines is about the same.

19. Yes, twenty per cent.

20. Yes, cylinders, guides, cross-heads, stuffing-boxes, about twenty per cent of these parts.

21. No.

22. Believe the compound engine is economical regardless of the price of fuel.

23. One dollar and eighty-five cents per ton.

24. Dynamometer tests show a much more uniform drawbar pull for the compound doing heavy work at low speeds. Portion of diagram attached herewith showing engines working compound and simple. (See Fig. 23.)

25. Yes.

26. Steel with cast-iron bull ring.

27. Intelligent care and adaptation to service. Most of our improvements in construction have been in better ratio of cylinders, improved construction of piston valves, cross-heads and guides.

28. Intercepting valves, cross-heads, piston and valve-rod packing and relief valves.

29. No.

GENERAL REMARKS.

There are some very decided advantages in the compound locomotive over the simple that make it very desirable and to attain which is worthy of a great deal of study and experiment.

1. In considering the ultimate capacities of locomotives, the ultimate capacity of the fireman is improved to the extent of the greater economy to be had, which results in a decided transportation economy.

2. It makes longer runs for water and coal possible.

3. Very much decreases the liability of fire along the right of way.

4. It provides a more uniform distribution of power throughout the stroke.

5. At high pressures the losses taking place with a simple engine on account of steam blowing past the piston packing are reduced in the compound, inasmuch as if the steam blows past the high-pressure piston it is used in the low-pressure cylinder.

LETTER NO. 4.

1. Two Baldwins, four-cylinder compound; one Richmond, two-cylinder compound; one Schenectady, two-cylinder compound; all ten-wheeled freight engines.

2. Engines all been in service about eight years, that is, since 1892.

3. We estimate about twenty per cent fuel economy in freight service.

4. We think the greatest economy is in freight service, and the best results can be obtained from roads with light grades and a large amount of level line.

5. We do not think compounds are quite as flexible, as regards service, as simple engines.

6. Compounds use the same size wheels in these cases as simple engines.

7. Compound engines are pooled the same as simple engines.

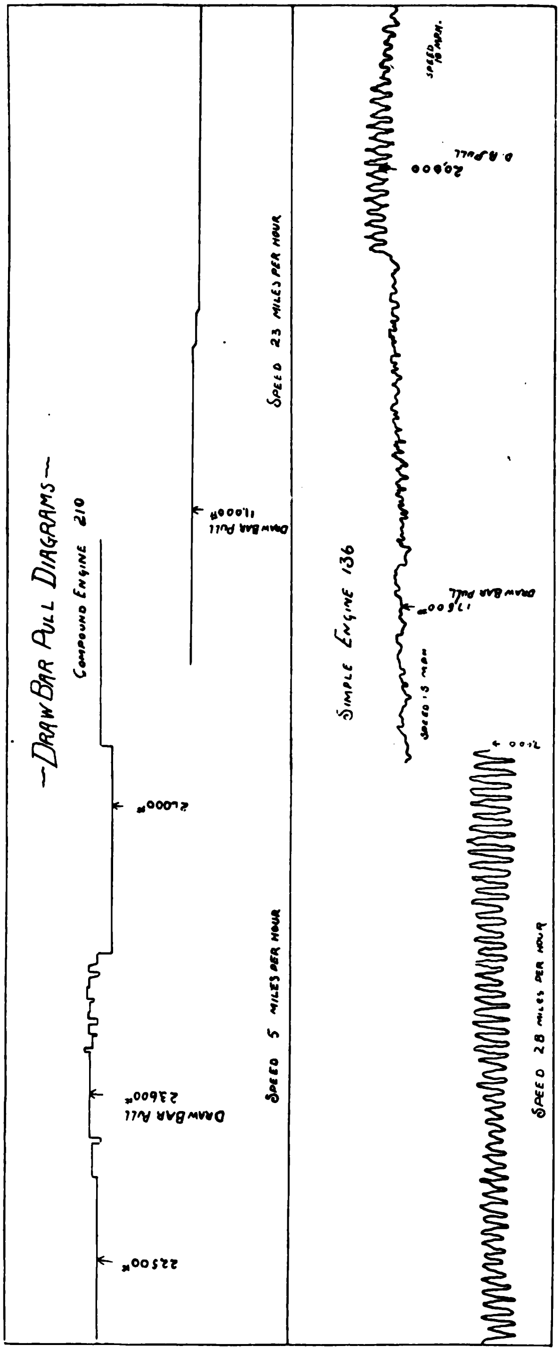

—DRAW BAR PULL DIAGRAMS—
COMPOUND ENGINE 210
22500#
DRAW BAR PULL 23600#
21000#
SPEED 5 MILES PER HOUR
DRAW BAR PULL 11,000#
SPEED 23 MILES PER HOUR
SIMPLE ENGINE 136
SPEED 28 MILES PER HOUR
2100
SPEED 15 MPH
DRAW BAR PULL 17,600#
D.B. PULL 20,800
SPEED 10 MPH.
HORIZONTAL SCALE 100' = 1"

FIG. 23.

8. We make no distinction ordinarily between the weight of train hauled by simple and compound engines of the same weight.

9. No. 8 answers this.

10. We consider the correct cylinder ratio from 2.3 to 2.8.

11. We consider manual control preferable to automatic control, as it gives the engineer better facility for handling the engine, and maintains it stronger for an indefinite period when starting.

12. No.

12½. Think there may be some less danger on account of the milder exhaust.

13. Engines will run smoother when cylinders are relieved, but many devices such as by-pass valves, etc., for this operation have proven unsatisfactory.

14. Have used both piston and slide valves. As a general rule think piston-valves give less trouble, particularly on low-pressure cylinder, where the slide valves are so large.

15. Compounds and simples of the same class carry practically the same steam pressure.

16. Compounds are worked simple when starting and up heavy grades.

17. As far as we can ascertain, compound engines are not worked simple except in running at very high speeds in order to prevent stalling.

18. Compounds have been out of service somewhat more than simple engines, but more due to the fact that we do not have the material on hand for proper maintenance that we have with the large number of simple engines we have on our road.

19. Some of our Master Mechanics think that there is a decided saving in maintenance in favor of compound engines with same pressure, but can not give any definite figures in answer to this question.

20. Some of the compound engines seem to pound a great deal heavier than simple engines, and in a way it is more difficult to keep up the boxes and brasses.

It is also sometimes difficult to keep the high-pressure piston-rod packing tight.

21. Compound engines seem to use about seventy per cent more cylinder oil than simple engines in the same service, and the total cost of lubrication amounts to about twenty per cent more than the simple engine.

22. There is no question but that the conditions you state, whereby economy from coal consumption would be overcome by increased maintenance and repairs, is a possibility.

23. One dollar and eighty-five cents.

23½. Same sized nozzle on compound and simple engines of the same weight.

24. Attach a statement of test made on our testing plant, as requested:

	SIMPLE.	SCHENECTADY COMPOUND.	BALDWIN COMPOUND.	RICHMOND COMPOUND.
Engine number........	797	819	820	836
Cylinder and stroke	19'' x 24''	20''x32''x24''	14''x20''x24''	19''x30''x24''
Diameter of drivers....	63''	63''	69''	63''
Date of test...........	June 10, '96	Dec. 28, '96	Nov. 12, '96	Nov. 18, '96
Duration of test	3 hours.	2 hours.	3 hours.	3 hours.
Miles per hour	16.84	14.91	22.22	23.7
Revolutions per minute.	89.8	81.4	100	107
Indicated H.-P........	699.32	H. P. 207.9 L. P. 327.2 535.1	526.39	H. P. 221.8 L. P. 283.6 505.4
Pounds coal per sq. ft. grate area..........	114.08	70	65.1	64
Pounds coal per sq. ft. heating surface.....	1.9	1.22	1.18	1.11
Pounds coal per H.-P. hour...............	4.2	3.52	3.8	3.4
Water per pound coal, from and at 212°.....	7.08	7.52	7.24	7.52
Water per H.-P. hour..	24.6	21.48	22.5	20.88
Boiler pressure.......	183.3	182.2	180.7	179
Cut-off..............	10''	H. P. 13'' L. P. 14''	H. P. 13⅜'' L. P. 14¼''	H. P. 13¾'' L. P. 14¾''
Grate area............	27 sq. ft.	27 sq. ft.	30¾ sq. ft.	27 sq. ft.
Heating surface........	1,711 sq. ft.	1,545 sq. ft.	1,609 sq. ft.	1,711.68 sq.ft.
Kind of coal..........	Hazel Creek.	Jackson Hill.	Jackson Hill.	Jackson Hill.

25. I think it very doubtful if compound engines as powerful as simple engines can be built of all types without some serious objections.

26. Perhaps cast steel of box shape and well ribbed is best for the center, with a cast-iron bearing surface on the outside for low-pressure pistons.

27. We think that the tendency of some locomotive builders to use piston valves, particularly in connection with the high-pressure cylinder two-cylinder compound locomotives, is quite an improvement over the old slide valves, which are necessarily of large size. We believe that the seeming tendency toward manual control instead of an automatic is an advantage, as above explained, and also decreases the number of delicate mechanisms necessary for this type of engine.

28. Lack of adhesion when running simple when sufficiently cylindered for the weight when compound we think is quite an objectionable feature with the present compound locomotives in service. Another objection is the fact that the manipulation is somewhat different from simple engines to which most of the men are educated and also the difficulty of carrying repair parts for a small number of engines which are entirely different from the regular stock used in repairing simple engines. Of course this latter is not a valid objection, but has some weight where only a small

number of engines are in service. This, of course, prevents largely transferring engines of this type from one division to another.

We also think that the great weight of reciprocating parts and unequal piston pressure on high and low pressure cylinders are points that are quite objectionable in compound engines. Many of them need too much careful work in such parts as reducing and intercepting valves, and the additional cost of parts needed for repairs also affects these engines unfavorably.

29. No.

LETTER NO. 5.

I beg to acknowledge receipt of your favor of February 27, with reference to our experience with compound engines. It gives me very much pleasure to furnish you with the results of that experience. I attach statement showing the performance of the simple and compound freight engines of precisely the same class, weight of engine being 150,000 pounds loaded, 135,000 pounds on drivers, 15,000 pounds on pony truck, engine being eight-wheel connected consolidation engine. Cylinders of engine No. 14, 22 by 28, and of engine No. 1, 14 and 24 by 28; engine No. 14 about one year older than engine No. 1. The statement shows results with these engines from 1892 to 1898 inclusive, and also for the single year of 1899. In the latter year, as you will notice, car miles were very much to the advantage of engine No. 1, but that is due to a great extent to the fact that we gave her the runs which would insure the heaviest trains, so that the advantage in fuel over engine No. 14 for the year 1899, or about 45 per cent, is not altogether fair. The advantage of 25.5 per cent in fuel over engine No. 14, as shown in the first statement, is nearer the truth.

COMPARATIVE STATEMENT OF PERFORMANCE OF SIMPLE AND COMPOUND FREIGHT ENGINES.

YEARS OF 1892 TO 1898, INCLUSIVE.

ENGINE.	MILES RUN.	POUNDS COAL PER ENG. MILE.	COST OF REPAIRS AND CLEAN'G.	COST OF COAL.	COST OF STORES.	TOTAL COST.	CAR MILES.	AV'GE NO. CARS PER MILE.	POUNDS COAL PER CAR PER MI.	AV'GE COST PER CAR PER MI.
1....	132,432	127.11	$7,496.62	$17,015.64	$976.79	$25,489.05	2,910,115	21.97	6.79	$0.88
14...	107,554	153 25	6,773.69	16,396.36	816.45	23,986.50	2,266,597	21.07	7.27	1.06
YEAR OF 1899.										
1....	24,526	124.01	$1,595.71	$2.494.38	$136.25	$4.226.34	511,115	20.84	5.95	$0.80
14....	30,920	133.74	1,367.70	3,376.78	145.20	4,889.68	479.525	15.51	8.62	1.02

Engine 1 is a compound engine.
Engine 14 is a simple engine.

I calculate if we had been able to keep the engine in tighter shape, the advantage in fuel over the simple engine would have been from 28 to 30 per cent. We will receive in a few months a new compound of the same class, but with the improvements that have been made up to this time, so that I think the results will be better still, as our engine No. 1 was among the earliest Vauclain compounds turned out.

I answer below the questions noted in your favor, seriatim.

1. We have had eight years' experience with a Vauclain heavy compound freight locomotive, described more fully above.

2. Answered in Question 1.

3. Our experience shows a saving of 25 to 30 per cent in fuel in freight service. I do not see why the same results should not be obtained in passenger and shifting service.

4. We find that the advantage in the economy of fuel is not affected by either grades or level running roads, as I think you understand the whole thing is based on the economical using of the expansive power of steam, which, in the case of steamships, is used up to quadruple expansion, and in my opinion, therefore, grades or lack of grades would not affect the operation.

5. We find a compound engine more flexible than the same class of simple engine; very quick in action. In fact, this is one of the strong points in its favor.

6. Same size driving wheels used as on a simple engine.

7. We practically have had two, or no more than three, engineers regularly running our compound. On a large road, in the pooling system, unless the engines were all compounds, it is possible that the best results would not be obtained. This, I think, would be more due to the men than the engines.

8. We do not find that the compound will haul any more than the simple engine. We rate them the same on tonnage basis.

9. Answered by No. 8.

10. I am not able to say, except that in the compound we have, as will also be the new one, the cylinders are 14 and 24 inches in diameter, respectively, which seems to be the ratio determined by Mr. Vauclain.

11. The change from simple to compound in our engine can only be done manually. I do not know that the Vauclain has any other method. I have never heard of it. I do know that the compound engine now in use on the Pennsylvania Railroad, on Conewago local, pulled a train over a portion of our line and stuck dead on an easy hill, engineer claiming that the "compound flew off," and he had considerable trouble afterward in starting even half his train, and stated that this is frequently the case. The compound is similar to the "Richmond," which has one high pressure and one low pressure cylinder.

12. The large cylinders undoubtedly draw in smoke from the smoke box, but we have not had any trouble on account of drying up lubrication, cutting valve seats, cylinders, etc., from this cause.

12½. The compound seems to throw more fine sparks from her stack but throws them so high that they are dead before striking the ground. We have had no trouble with her setting fires.

13. Our engineers relieve the cylinders while drifting down hill, etc., by putting the lever in the straight steam position. This has been found to be the best method to accomplish this after they had tried most everything.

14. We use the piston valve on compound, as that is the only valve the Vauclain compound is equipped with, according to my understanding.

15. Simple engine carries 140 pounds and the compound 180 pounds steam pressure.

16. In starting a heavy train from a station or pulling an unusually heavy train over heavy grades, compound engine is worked simple. At all other times she is worked compound.

17. This has been stated as an objection to the compound, that engineers would do so. Our instructions, however, are very strict, and I think our engineers work the compound simple only when necessary.

18. Our experience does not show that the compound engine is out of service oftener than the simple engine, as you can also see from the attached statement. As stated, this engine was one of the earliest compounds and the biggest end of the changes and repairs made to it was within the first year, due to changes found necessary. Another thing, this engine has been shopped several times on account of broken frames. This was due, not to the fact that it was a compound, but that the frames were entirely too light for that class of an engine, simple or compound. Our new compound will have a heavier frame and we think the results will be much better than with our present engine.

19. We find that the maintenance of tubes and other boiler work is less for the compound than for the simple engine of the same class. As 28 per cent less fuel is used and about that proportion less water is used, we think the same proportion holds good in the boiler work, probably a little higher.

20. We do not so find it.

21. Cost of lubrication is about the same.

22. Answered by three previous questions.

23. Present price of soft coal, which is our fuel, will average $2.25 per ton.

23½. Compound engine, double nozzle, 3½ inches in diameter each. Simple engine, double nozzle, 4 inches in diameter each.

24. We have not made such tests.

25. We think it is practicable to increase the size of compound as well as simple engines, enlarging the pistons and rods proportionately. Our compound piston rod is 3½ inches in diameter in both pistons. Simple engine is 4 inches in diameter. The boiler sheets of the compound engine 11-16 and of the simple engine 10-16, which, of course, is the same in the cylinders. As to the larger size of piston rods, etc., I do not think the Baldwin Locomotive Works increase this size proportionately with the diameter of the cylinder as much as do the Pennsylvania Railroad in their standard engines, and it may be one point of weakness in the Baldwin engine.

26. Our pistons are of cast iron with solid head, which we think the best on account of having no follower bolts to drop off in the cylinder.

27. One trouble we had with our old compound was the inability to keep the cylinder heads and cylinder cock arrangement tight enough to prevent the constant escaping of steam, which clouded everything in front of the engine. Our new engine now being built will have one-third more stud holes in the diameter of each cylinder and the piston valve, which we think will overcome this objection, and improvements have also been made in the cylinder cock arrangements which will tend, we think, to keep them tighter. This, in connection with the heavier frames, we think will make us a much better engine than we now have.

In the assignment, handling or disposition in service, I do not know that we will make any difference, except keep as much as possible not more than two men running our compound engine.

28. Answered by 27.

29. We have not, and from our experience I do not think we would change our compound engine to simple engine.

I note what you say in your letter as to the trouble on account of your pistons, cross-heads and cylinders breaking. This might be due to the fact that the rods are not heavy enough, and pistons having follower plates breaking heads on account of follower bolts breaking and dropping into the cylinder, thus blowing out your cylinder heads. I do not understand, however, why this should be more the case with compound than simple engines of the same weight and class.

Our compound engine in 1892 cost $1,300 more than the simple engine in 1891, and material cost about the same. This difference in cost was due to compound arrangement. Our first record on enclosed statement is, as you notice, for seven years, and the cost of repairs was about the same, taking into consideration the additional miles run by the compound. The difference in cost of $1,300 for seven years at 6 per cent would be $546. Had engine No. 14 done the same work as did engine No. 1, she would have used 25.5 per cent more fuel, which would have cost $4,338. This leaves a credit to the compound engine of $3,092 for seven years, and, as stated above, we think the new engine will show still better results. I shall be glad to give you any other information in this connection that I am able.

LETTER NO. 6.

1. Yes. Thirty-one two-cylinder consolidation and ten-wheel locomotives.

2. Seven years.

	No. of engines.	Length of time.
In freight service	26	7 years.
In passenger service	5	2 years.

3. See enclosed statement.

COMPARATIVE STATEMENT, SHOWING COST OF REPAIRS AND FUEL FOR MOGUL, COMPOUND AND SIMPLE CONSOLIDATION ENGINES FOR THREE YEARS, 1896, 1897 AND 1898.

	MOGULS.		COMPOUND CONSOLIDATION.		SIMPLE CONSOLIDATION.		MOGULS, ALL CLASSES.	COMPOUND CONSOLIDATION ALL CLASSES.	SIMPLE CONSOLIDATION ALL CLASSES.
	RHODE ISLAND.	BROOKS.	RHODE ISLAND.	SCHENECTADY.	RHODE ISLAND.	SCHENECTADY.			
Engine miles..........	666,066	714,806	1,027,008	1,189,666	73,559	81,015	1,380,872	2,216,674	154,574
Ton miles hauled......	327,467,374	372,191,459	818,919,719	894,551 590	59,343,059	70,919,045	699,658,833	1,713,471,309	130,262,104
Average number of tons hauled per eng. mile	491	520	797	752	806	875	507	773	842
Total cost repairs......	$38,729.34	$35,309.72	$62,101.70	$71,201.12	$5,918.04	$5,350.09	$74,039.06	$133,302.82	$11,268.13
Cost repairs per eng. mi.	$0.0581	$0.0494	$0.0604	$0.0598	$0.0804	$0.066	$0.0536	$0.0601	$0.0729
Cost repairs per 10,000 ton miles...........	$1.18	$0.95	$0.758	$0.795	$0.997	$0.754	$1.06	$0.778	$0.865
Total cost of fuel......	$71,580.93	$76,971.23	$118,087.22	$132,979.06	$10,425.34	$11,967.20	$148,552.16	$251,066.28	$22,392.54
Cost of fuel per 10,000 ton miles...........	$2.18	$2.07	$1.44	$1.49	$1.76	$1.69	$2.12	$1.46	$1.72
Total cost of fuel and repairs per 10,000 ton miles...............	$3.36	$3.02	$2.20	$2.28	$2.75	$2.44	$3.18	$2.24	$2.58
Number of engines....	8	8	12	14	1	1	16	26	2
Average miles per year per engine..........	27,752	29,783	28,528	28,325	24,519	27,005	28,768	28,419	25,762

Using the compound consolidation type as a basis, the mogul engines haul 34 per cent less tonnage per mile, costing for repairs 36 per cent more, and for fuel 45 per cent more, per 10,000 ton miles.

The simple consolidation engines haul 9 per cent more tonnage per mile, costing for repairs 11 per cent more, and for fuel 10¾ per cent more, per 10,000 ton miles.

Cost of fuel for Rhode Island compounds is 18.18 per cent less than for Rhode Island simples.

Cost of fuel for Schenectady compounds is 11.83 per cent less than for Schenectady simples.

4. Figured on ton-mile basis, compounds show greatest fuel economy in freight service. In my opinion, they can be used to greatest advantage on roads with low gradients.

5. Two-cylinder compounds are not as well adapted for switching as simple engines.

6. In determining the size of wheels we do not take into consideration whether an engine is compound or simple.

7. We treat compounds the same as simple engines.

8. No.

9. ———

10. We have found that ratios of 1 to 2.3 in freight service and 1 to 2.5 in passenger service have given very good results.

11. The operation of the intercepting mechanism should be under the control of the engineer, so as to get the increased power when you want it. We have operated both types, and engines with intercepting valves controlled by engineer haul fifty tons more per train than engines with valves that work automatically.

12. Yes, we have experienced some difficulty in this respect.

12½. Yes.

13. Yes, with air relief valves on cylinder heads.

14. We use slide valves only, Richardson and American Balanced, but with high pressures believe that piston valves would give better results.

15. Yes.

16. For short distances on maximum grades.

17. Yes, we have found that they do.

18. No.

19. Yes.

20. We find no difference.

21. Our experience shows that simple engines cost more for lubrication than compounds.

COST OF OIL AND WASTE PER ENGINE MILE IN CENTS.

	1897.	1898.	1899.
Schenectady simple	.28	29	26
Schenectady compounds	.26	25	25
Rhode Island simple	.31	32	39
Rhode Island compounds	.27	28	30

22. You will notice from enclosed statement that our cost of maintenance for compound engines is less than for simple engines of same class. It therefore follows that compounds are the most economical, irrespective of the cost of fuel.

23. Two dollars and twenty-two cents per ton.

23½. No. The size of exhaust nozzle is practically the same.

24. Have not made any tests that would be of value to you.

25. My experience so far will not allow me to say.

26. Cast steel.

27. The most important improvement in compounds have been in the intercepting valve. Some of the old designs were very inferior and some automatic in their operation. Later patterns of valves are more accessible and their operation is under the control of the engineer, which, in my opinion, is a very important feature. Also on recent compound engines the ratio of cylinders are better proportioned than formerly.

28. The weak or defective points that develop in earlier compounds have been so well taken care of on the more recent engines that I have no suggestions to offer in this direction.

29. We have converted no compounds to simple engines. In fact, we have just converted one simple engine to compound, and are about to change another.

I will add that from our experience with compound locomotives during the past seven years we believe that they are far more economical in operation and maintenance than simple engines, and if our compound engines, built in 1893, had been proportioned same as those of recent construction, we would have made a much better record in cost of repairs and cost per ton mile.

LETTER NO. 7.

1. We have eighty-three Baldwin four-cylinder compounds and one Cooke two-cylinder compound, these engines being made up as follows: Eighteen Atlantic type high-speed passenger, having 26-inch stroke; forty-eight eight-wheel passenger, having 22-inch stroke (these engines being remodeled from old eight-wheel engines); eleven fast freight ten-wheel engines; six Decapod pusher engines, all of which are of the four-cylinder type, and one eight-wheel two-cylinder compound remodeled from an old engine have 24-inch stroke. All of the ten-wheel engines have 24-inch stroke and Decapods have 28-inch stroke.

2. One of the ten-wheelers was purchased in 1890 and is equipped with a Wootten boiler. The other ten were purchased in 1893 and have fire-boxes full width of the frames. The Decapods were purchased in 1891-1892 and are equipped with Wootten boilers, as are also the eighteen Atlantic types and forty-nine eight-wheelers. The forty-eight eight-wheel engines were modeled and placed in service about three years ago. Four of the Atlantic types have been in service about eighteen months and fourteen of them about six months. We have no compound engines engaged in switching service.

3. We do find a fuel economy in the operation of the compound engines, but we believe that this saving is due to our ability to burn an inferior grade of coal and thereby save considerable in the price paid per ton. (See statements accompanying this report.) I believe considerable of our saving in coal is due as much to the Wootten type of boiler as to the compound cylinders.

4. Our greatest fuel economy is shown in our Decapod locomotives and with the Wootten type of boiler; the gradients of the line do not cut much

COMPARATIVE STATEMENT OF MILEAGE AND EXPENSES OF SIMPLE ENGINES 750–757 AND COMPOUND ENGINES 980–987. FOR THREE YEARS FROM TIME BUILT, JANUARY 1, 1894, TO JANUARY 1, 1897.

SIMPLE.	Total Engine Mileage.	Cost of Fuel.	Cost of Repairs.	Total Expense Including Fuel, Oil, Repairs, Wages and Other Supplies.	Freight Engine Mileage.	Loaded Freight Car Mileage.	Average Cost per Engine Mile, Fuel.	Average Cost per Engine Mile, Repairs.	Average Cost per Engine Mile, Total Expense.	Average Cars per Draft Freight.
750	165,829	$11,449.87	$5,283.96	$28,126.39	148,974	3,040,916	$6.90	$3.19	$16.96	20.4
751	....	....	....	....	....	....	....	....	....	....
752	....	....	....	....	....	....	....	....	....	....
753	197,379	11,760.82	4,788.89	28,753.82	181,917	3,990,225	5.96	2.43	14.57	21.9
754	177,449	11,195.52	6,084.29	28,369.73	161,538	3,725,563	6 31	3.43	15.99	23.1
755	....	....	....	....	....	....	....	....	....	....
756	130,787	9,261.08	3,122.12	21,365.36	103,209	2,013 001	7.08	2.39	16.34	19.5
757	123,639	9,293.18	4,086.17	21,912.78	105,815	1,987,225	7.52	3.30	17.72	18.8
Five engines....	795,083	$52,960.47	$23,365.43	$128,528.08	701,453	14,756,930	$6.66	$2.94	$16.17	21.0
Average per eng.	159,017	$10,592.09	$4,673.09	$25,705.62	140,291	2,951,386	....	....	....	....
COMPOUND.										
980	....	....	....	....	....	....	....	....	....	....
981	112,236	$8,125.28	$4,388.05	$20,322.07	109,648	2,129,741	$7.24	$3.91	$18.11	19.4
982	112,273	8,345.66	4,976.93	21,120.22	109.991	2,146,477	7.43	4.43	18.81	19.5
983	118,881	8,203.57	4,136 13	20,555.37	116,822	2,212,777	6.90	3.48	17.29	18.9
984	114,608	8,361.17	4,831.01	21,205.04	110,491	2,118,363	7.30	4.22	18.50	19.2
985	....	....	....	....	....	....	....	....	....	....
986	110,000	8,006.70	4,779.01	20,578.83	107,453	2,109,960	7.28	4.34	18.71	19.6
987	....	....	....	....	....	....	....	....	....	....
Five engines....	567,998	$41,042.38	$23,111.13	$103,781.53	554,405	10,717,318	$7.23	$4.07	$18.27	19 3
Average per eng.	113,600	$8,208.48	$4,622.23	$20,756.31	110,881	2,143,464	....	....	....	....

of a figure in coal consumption. I consider the compound engines of the four-cylinder type as working to their best advantage when pulling high-speed passenger trains and slow-speed pusher service, or in operation on level divisions.

5. Compound engines are not as flexible and as readily adapted to various kinds of service as simple engines, as the men must be educated to handle these engines properly to get the best results from them.

6. We do not use larger driving wheels on compound engines in freight service, but on high-speed passenger engines we use the 78-inch diameter wheel, but have the same size wheels on seven simple engines engaged in practically the same service. The simple engines, however, are not equipped with Wootten boilers and therefore are not able to burn as cheap a grade of coal and thereby effect the fuel economy which the Wootten engine gives us.

7. We do not pool compound engines; they are assigned to regular crews and in many cases three engineers are handling the one engine.

8. The train rating of compound engines in freight service is no higher than with simple engines having the same draw-bar pull.

9. Our rating for compound engines is no higher than for simple engines, as the compound engines will develop their maximum draw-bar pull more in working compound than in working simple.

10. We use the Baldwin Locomotive Works' regular practice for the ratio for diameter of cylinders and buy all our cylinders for repairs from them.

11. Manually operated intercepting mechanism is superior to the automatic, because we can get better results therefrom in starting a train.

12. No.

12½. Less danger of compound engines setting fires than from simple.

13. We open cylinder cocks of our compound engines while operating through yards, but while drifting down hills we allow a slight amount of steam to pass through the cylinders to prevent pounding, but this I believe is being overcome by the introduction of larger relief valves.

14. All our compounds are equipped with piston valves.

15. The compounds and simple engines between which we make comparisons carry the same steam pressure.

16. Compounds are worked simple only at starting.

17. No.

18. Yes. See statement attached.

19. The cost of maintenance of boilers is practically the same for simple and compound locomotives so far as we can see, except in the bad water district, where we find the life of flues in the compounds considerably greater (probably 10 per cent) on account of less bad water evaporated through the boiler.

20. We cannot find any difference in the cost of maintenance of machinery between the simple and compound engine.

21. The cost of lubrication is slightly greater with the compound

engines than with the simple on account of the greater amount of cylinder surface to lubricate.

22. It might.

23. The average cost of coal per ton where we are using compounds varies from 99 cents to $1.69 per ton, according to the distance from the mines, the total average being $1.38 per ton. Our cheaper coal, however, is a mixture of refuse culm from the hard coal mines mixed with 25 per cent of soft coal slack.

23½. Compound engines use a larger exhaust nozzle than simple engines of the same power.

24. We have never made any careful dynamometer or indicator tests of compound engines.

25. I consider it practicable to build compound engines of corresponding hauling capacity to simple engines.

26. We make no difference in material and design for low-pressure pistons in compounds and simple engines having large cylinder area.

27. The most important improvements that have been made in compound engines since their introduction is their ability to make high-speed passenger service regularly and easily, and they have wonderful ability in picking up lost time account of detentions.

28. The weak and defective points which have developed with us have been mainly in the cross-heads and connections for the intercepting valves. We have strengthened these parts with material benefit and also have added cylinder cocks to both high and low pressure cylinders with beneficial results.

29. We have not converted any compounds to simple engines since their purchase, but are considering the changing of the two-cylinder compound into a four-cylinder type, as we find that the four-cylinder type gives us better service.

I and 2. COMPOUND ENGINES IN SERVICE. January, 1900.

NUMBER OF ENGINES.	SERVICE.	CLASS.	TYPE.	BUILDER OF ENGINE.	BUILDER OF COMPONENT PARTS.	TOTAL WEIGHT OF ENGINE.	YEAR PUT IN SERVICE.	AVERAGE NUMBER OF MONTHS IN SERVICE.
* 1	Freight	D3	4 Cylinder mogul	Baldwin	Vauclain	104,400	1896	41–46
* 3	"	D3	2 " "	"	Brooks Richmond Pittsburg	104,500	1896	37.6–42.6
* 1	"	D5	2 " "	"	Schenectady	120,500	1897	26–31
* 3	"	F1	4 " Consolidation	"	Vauclain	150,000	1896	38.6–43.6
4	"	X	2 " Mastodon	Schenectady	Schenectady	186,000	1897	35–40
20	"	R	2 10-wheel	"	"	172,500	1897	29.1–34.1
16	"	S	2 10- "	"	"	173,800	1898	16.8–21.8
14	"	S-1	2 10- "	"	"	177,000	1899	5–10
14	"	Y	2 Cylinder Consolidation	"	"	186,000	1898	13.2–18.2
8	"	Y	2 " "	"	"	190,600	1899	3.5–8.5
1	Passenger	P	2 " 10-wheel	"	"	155,500	1897	29–34
8	"	P	2 " "	"	"	155,500	1898	22–27
4	"	P-1	2 " "	"	"	160,400	1899	5–10

97, total number of compound engines.

* Converted from simple engines.

3. Saving per ton-mile in heavy freight service, 15 to 25 per cent over simple engines of corresponding weight and steam pressure. We have no compounds in use for switching service.

4. Compound engines have shown a fuel economy in all classes of road service on this road wherever they have been used. This service has varied from heavy freight service on undulating grades to mountain service on long grades of 116 feet to the mile. Also on passenger service on the same kinds of grades. The economy has been greater in slow, heavy freight service than in passenger. Compounds will show greatest fuel economy on a division the grades of which are such that the tractive power can be most continuously utilized to the largest extent.

5. Yes, except in switch service.

6. Same size of drivers used on compounds and simple engines of the same class in both passenger and freight service.

7. Pooling of locomotives and crews is practiced on some divisions, particularly at seasons of the year when business is heavy and number of engines limited. In some cases engineers are assigned to certain engines but the number of engines not agreeing with the number of engineers, the same engineer would not hold the same engine on each trip. On some divisions, in ordinary conditions of service, engineers are assigned to certain engines. Where engines are pooled, the compounds are included with the simples.

8. Simple and compound engines of corresponding weight should have the same train rating, provided cylinders are properly proportioned to weight on drivers. The high-pressure cylinder of the compound engine should be slightly larger than either cylinder of corresponding simple engine to give the same power, if the compound is of the two-cylinder type. There are certain conditions in which the train-rating of the compound may be slightly increased over the simple as specified in answer to the next question.

9. Simpling of compound engines should only be done when necessary in emergency cases or where necessary at regular points for very short distances to help a train over a maximum grade. If these maximum grades are short, and there are long distances of easy working, it is allowable to simple the engine as above indicated. In such cases the rating of the compound engine will be slightly increased over corresponding simple engine.

10. The ratio of diameter of compound to simple cylinders in two-cylinder compounds for freight service varies from 1.48 to 1.54.

11. Intercepting valves that can be thrown into simple at will by the engineer give the best service. By this means the power of the engine can be increased for short spurts at the will of the engineer.

12. Not sufficient to cause any trouble.

12½. Less danger of setting fire with the compounds.

13. Small drifting throttle applied to nearly all compound engines in our service. This is an auxiliary throttle admitting a small quantity of

steam to cylinder when main throttle is closed. This should always be opened in drifting down long hills. All cylinders have relief valves and engines with piston valves have a by-pass valve, establishing communication between ends of cylinders and steam chests when cylinder pressure becomes greater than steam-chest pressure. This may occur at the compression end of stroke.

14. More recent compounds have piston valves on high-pressure side; older engines have slide valves on both sides. Results very favorable to piston valve for high-pressure steam.

15. Same steam pressure.

16. See answer to question 9.

17. No.

18. No. Figures made last fall, including all compound engines that have been in service since beginning their use in 1896, compared with simple engines during same period, indicated that compounds did not receive more repairs than simples.

19. Experience with compounds has not yet been sufficiently long to show any appreciable difference in boiler repairs as compared with simple engines in same service.

20. Do not find cost of machinery repairs any greater with compounds.

21. Lubrication of compounds generally less than with simples.

22. Our experience is no increased cost of maintenance but a decided decrease in cost of fuel consumption.

23. One dollar and sixty-five cents per ton, exclusive of freight on our own line.

23½. Exhaust nozzle no difference.

24. Dynamometer and indicator tests of compounds have shown the same general fuel economy as stated in No. 3. Indicator cards have shown the necessity of some changes in valve motion to make even distribution of power with two cylinder compounds. Indicator cards have also shown excessive compression on low-pressure side of compound passenger engines at high speeds, which was considerably relieved by cutting out inside clearance of low-pressure valve to ½-inch. Indicator cards show that two-cylinder compounds will not run as freely at high speeds, due to the large cylinder being unable to free itself of steam as readily as the smaller cylinders.

25. We consider it practicable to build compound engines equal in hauling capacity to any of the modern simple engines, except possibly in comparison with one or two of the very largest modern simple freight engines. If engines of larger power than any of the largest now built are contemplated, it would seem that tandem or other types of compound would be necessary.

26. Cast steel Z-plate piston.

27. Perfecting of intercepting-valve arrangements to relieve low-pressure cylinder while drifting and use of piston-valve on high-pressure cylinder.

28. Intercepting valves fail at rare intervals due to abuse when dash pots are not kept filled with oil. Two-cylinder compounds develop excessive compression at high speeds in low-pressure cylinder. Equalizing of distribution for all cut-offs both four-cylinder and two-cylinder compounds.

29. One old-style four-cylinder compound changed to simple account of cylinders needing heavy repairs and compounding features not being in accordance with latest improvements of this type of engine.

Since the compilation of this report, a letter has been received by the committee from one of the members giving a comparative statement of the performance of a simple engine and a Richmond compound on the same run for the period of three months — December, 1899, January and February, 1900 — wherein it is shown that the simple engine made 20,799,495 ton-miles at an average cost of .000324 cent for labor, fuel and lubrication, while the compound made 9,304,335 ton-miles at an average cost for labor, fuel and lubrication of .000312 cent. The total, 30,103,830 ton-miles at the average for the simple engine (.000324 cent), would cost $9,753.64; at the average for the compound engine (.000312 cent) would cost $9,392.39, or a saving in favor of the compound of $120 per month. The coal cost $1.37 per ton.

To lessen the labor of any one who might wish to make a study of the subject of Compound Locomotives, a list of references to the literature upon the subject is appended to the report here given.

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New P. R. R. Compound	Oct.	154
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	DATE.	PAGE.
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	DATE.	PAGE.
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Mr. Deems: In the appendix appear some letters in full under numbers, not giving the names. That was due to the fact that three of those writing requested that their names should not appear, and it was thought that if all the names could not appear it was best that none should do so. I would say that these letters contain very valuable information.

The President: Gentlemen, what is your pleasure with the report?

Mr. Henderson: I move that the report be received and opened for discussion.

The motion was carried.

The President: The report is now open for discussion.

Mr. Morris: Mr. President, this committee, I think, should be congratulated. I believe it is one of the healthiest reports on the compound engine that we have ever had, and while there is some little evidence of dyspepsia, according to our own ideas, as I said before, the committee has done a very good work in this direction.

In going over the conclusions arrived at from the replies to the circular of the committee, there are some points I would like to take exceptions to as not entirely coinciding with our experience. One of these points relates to the reply to question 5, where it reads, that the compound is not so flexible as the simple engine. The word " flexible " was misinterpreted in our answer to the committee and our reply was framed as though the question referred to " adaptability of service." The matter of curvature, easy riding and comfortable adjustment of the compound to track conditions have never been questioned — in fact, all comment being favorable to the compound in this direction.

Question 6. We would recommend as large drivers on the compound as possible, to reduce piston speed.

Question 9. The rating should not be higher for the compound than for the simple engine of same tractive power, and its conversion into simple should not be resorted to, except in starting or to prevent stalling in case the proper load is exceeded.

Question 11. For some unexplainable reason, a great deal of stress has been laid upon " manual control of the compound feature." It is not clear what this really means, but we would call it the emergency feature, and it should be under control; in other words, operative at the will of the engineer. It is not good practice, we believe, to introduce an additional lever to that of the throttle and reverse lever for the engineer to operate at every start, when not needed, as in eight years' experience with the compound locomotive we have not found a single occasion for its use other than as just indicated — for emergency. The principle of manual control cannot be fully applied under any circumstances, as the starting device of any acceptable design must have an automatic reducing valve. This is the most important valve in the whole device, and the chances for a possible sticking are no greater in one case than in the other. In fact, we have yet to hear of the first occurrence of any disarrangement of either after the cylinder has been properly cleaned of molding sand in the steam passages.

Question 13. Reference is made to by-pass valves, which we consider as an absolute necessity for a successful compound, and the larger the opening in the valve the better. We are using valves of four inches in diameter for 32-33-inch cylinders, and by careful investigation it is found that a reduction of forty to fifty per cent in the vacuum in the smoke box is obtained by their use. It is not necessary to have any supply of fresh air through the steam chest relief valve in connection with the by-pass valves, as, by its removal, a further reduction of the vacuum would be obtained, which we, however, have not found necessary to do. There is no question but that suction or vacuum in the cylinder can be removed by slightly opening the throttle, as some advocate; but this has the same effect of fanning the fire as has a sufficient supply of external air, and which is the very evil that we want to remove. So far as we know, there is no other method suggested that will accomplish this as well as the by-pass valve.

Question 17. In the earlier introduction of the compound considerable abuse of the emergency feature was entertained, from the fact that they were positively overloaded in every instance, but this condition has righted itself with us, and there is now absolute protection given this feature by the enginemen, and the emergency, or simplifying of the compound, with us, is a rarity, and only at times when emergency absolutely exists is it used.

Question 21. We have found from our records the lubrication a trifle less on the compound, but think it advisable not to attempt to save on this item, but use about the same amount of lubricant as for the simple engine for like service.

Question 27. In connection with the remarks on improvements, we will mention that the intercepting valve we are using is of the same design as that used eight years ago, and we have not as yet found room or reason for improvement. The one referred to is working today as well as when it was first applied and has not cost a cent for repairs.

In the slide valve and steam distributions considerable improvements have been made. In this connection, I would refer to the application of the Allen valve, having the auxiliary port so arranged in relation to the two steam ports in the valve face of the cylinder that it serves as an exhaust port in the early part of the exhaust period, thus relieving the back pressure in the cylinder to a considerable extent, especially at high speed. By special investigation we have found an engine on which the double-ported valve — we call it double-ported valve so as to define it from the Allen valve — was put on in place of the old plain valve; a speed of 26 to 39 miles per hour indicated a gain of eighteen to forty-one per cent in power comparatively, and would undoubtedly have continued at that rate still higher if we had had cards from the plain valve for comparison at higher speed.

There are two peculiarities in the compound not brought into general notice, which are of inestimable value to the railroad, perhaps as much so as all the other advantages combined.

One of these is that of starting a heavy train, as compared with the simple engine. We have no apparatus with which to make a careful analysis of the difference in effect upon the cars and draft gears in starting with the two kinds of engines; but it needs no more than an ordinary observation to see that there is a material difference. In these days, when every engine is loaded down to the last pound, the simple engine can seldom start its train without taking its slack, and often repeat this process three or four times with the greatest possible acceleration in order to get momentum enough in the first part of the train to aid the starting of the rear. The consequent shocks to draft rigging and cars are too well known to need emphasis, and are probably the hardest part of the service, few riggings being strong enough not to be subjected to a strain far in excess of their elastic limit. Is not this condition largely responsible for the subsequent wreckage and hastening the ultimate ruination of the car, not to mention delays and repairs it has thus introduced during its curtailed existence?

The starting of the compound differs considerably in this respect from the simple engine, especially since enginemen have become familiar with the handling of the machine. There is no need of taking slack with the object of getting the aid of the momentum, and consequently the slack that generally exists in the train before starting is taken up with care and gentleness, and brings the engine to an apparent standstill about the time when all couplers are stretched. From this moment the actual starting takes place, and, as there is no lost motion left, there can be no appreciable jerks in the train. If the train is exceptionally heavy and is about to stall, the engine should be turned into simple at that point for a few revolutions of the wheels, or as far as may be deemed necessary to get the train under way. The initial acceleration being slower in starting automatically than in the emergency, the slack should preferably be taken up under automatic starting, as it is easiest on couplers and cars. This valuable advantage cannot be overestimated, as it necessarily reduces the repair expenses and prolongs the life of the rolling stock in general.

The other peculiarity is the possibility of utilizing from thirty-three to thirty-five per cent of the weight on the drivers for tractive power in emergency. This feature, however, is not so easily explained, but makes it possible to handle the trains under all conditions without resorting to the destructive utilization of the slack. (Applause.)

MR. POMEROY: Mr. President, I would like to ask the committee to explain what it meant by Conclusion No. 5: " The compound is not so flexible an engine as the simple." Whether it means its adaptability to various services or its relationship physically to the track and roadbed.

MR. DEEMS: It says: "Are compounds as flexible or as readily adapted to various kinds of service as simple engines of the same class? " I do not see why that should be misleading.

MR. POMEROY: The reason I asked the question was because I thought that the last speaker had narrowed it down to its adaptability physically to the track. I wanted to see if that is what the committee meant.

Mr. Sinclair: Mr. President, I believe I am responsible for that expression. When the first Schenectady compound was put in service on the Michigan Central Railroad I was invited to make a series of tests to see how it compared with a simple engine of practically the same class in various kinds of service. I worked for a considerable time testing the two engines under similar conditions with the same kinds of trains, and after I was done I was required to make a report to the president of the road regarding the engine. Of course, compounds have improved very much since that time, but my recollection is that I found the engine saved about from sixteen to twenty per cent of fuel in heavy freight service, did not save anything in passenger service and was not well adapted for light service of any kind. In making the report I used the expression that the engine was not so flexible as a simple engine, meaning that it was not so well adapted for all-around service. I think I used the expression " all-around service " in the same connection, and I have noticed that that expression has come into considerable use. That is the sense I used it in, that it was not like the old eight-wheel engine that we could put on any service, passenger or freight, and be equally efficient in all of them.

The President: Mr. Vauclain, can't we hear from you on this subject? (Applause.)

Mr. Vauclain: Mr. President, this is a much fought over subject — the subject of compound locomotives. The first time I had the honor of addressing this convention on compound locomotives was at Cape May in 1891. I believe at that time there were certain prophecies made in regard to the future of compound locomotives. I think that the prophecy which I made at that time has fairly well been borne out by what has been done during the past nine or ten years. I have carefully read the report of the committee appointed to report at this meeting, and I wish to compliment them upon the amount of work and general information compiled. There are some of the conclusions which I do not entirely agree with, but my disagreement with those conclusions is perhaps of minor importance when the full purport of the report is taken into consideration. I will simply call attention to one or two items, the first conclusion being the most important one from my standpoint. It is a conclusion that I think should be erased from the report. The builders of compound locomotives in the United States, with such a report as this going broadcast all over the world, are somewhat handicapped in the sale of compound locomotives in foreign countries. When we consider the state of the art in this country, I think that no one can take exception to changing the first conclusion to read as follows: "Compound locomotives have not been generally adopted by railroads in America, but are rapidly coming into use for both freight and passenger service." In defense of this alteration I wish to recite the condition of affairs that exists in our works today. We will, by the first of January next, finish 1,200 locomotives built this year. We have turned out for the first six months 600 locomotives, and it is fair to presume, with the additional facilities we are adding from day to day, that the remaining six months will see us with twelve hundred engines to our credit. Of this number probably from three to four hundred will be foreign locomotives and eight hundred will be domestic locomotives. Of the whole number some five hundred of these locomotives will be compound. This is definite, because the locomotives are practically all ordered; they are all in line; they are making for the railroads as fast as they can get through the tangle of a large building shop. If that is the case we have over fifty per cent of all the modern American locomotives built today built on the compound principle. And why should we state in the very first conclusion in our report that the compound locomotives in this country are merely gradually emerging from the experimental stage? I have taken the position before your honorable body that the experimental stage in compound locomotives was passed long ago. It certainly was passed long ago not only on the four-cylinder engine, which I have to stand for, but for two-cylinder compound locomotives as well. There are various types of two-cylinder compounds and all are giving good service. We see two-cylinder compounds and four-cylinder compounds changed slightly from time to time — small improvements; but show me the simple engine today that is not being constantly improved. Do we build our simple engines today as we built them ten years ago when we first started to build compounds? What railroad in the United States would equip itself with simple engines such as we built ten years ago? It would be the utmost folly. Therefore is it not reasonable to expect as we proceed and build compound locomotives that we are going to add improvements from day to day and from year to year in their construction? If we are engaged in doing this it does not follow that such improvements in the design can be attributed to these locomotives simply emerging from the experimental stage. If we take that view of affairs, we are going to be in the experimental stage with compound locomotives all our lives.

Now so far as trade is concerned — and trade is the principal thing with the United States today; without trade our railroads could not pay dividends, manufacturers would have to close up— it is just as important to railroad companies that the position of affairs in this country is correctly understood abroad as it is to the manufacturer or builder who undertakes to build for foreign countries and to furnish at a certain price. Therefore, if the superintendent of motive power of a foreign road, seeking for information, for a chance to save in his country, would take up the proceedings of the American Railway Master Mechanics' Association and the first item to meet his eye should be that compound locomotives in this country were merely emerging from the experimental stage, I am inclined to think that he would not be in favor of recommending his Government, or the private concern for which he might be working, to send to America and purchase fifty or one hundred compound locomotives.

To go one step further; take Russia, for instance. Russia has passed beyond the position that we are in today. The Society of Engineers in Russia have made their investigation and have decided that the four-cylinder compound is *the* locomotive — that is, that it is an acceptable locomotive for the Russian Government and its connections to buy. They do not say that the two-cylinder compound locomotive is not the engine, or that the simple engine is not the engine; they have been building two-cylinder compounds for years. A four-cylinder compound is sent them of a new design, a curiosity one might say in that country. They do not keep on using that one for ten years and at the end of ten years say: " We are just emerging from the experimental stage," but they decide definitely and they come out definitely and their roads are permitted to order these engines. The consequence is that these locomotives are not ordered in fives and tens but by fifties and hundreds. Steamer-load after steamer-load of these locomotives go out of this country every year. Similarly in other countries. Take the Government of Bavaria; the Government of Bavaria says: "What shall we do? We will buy two locomotives and we will see what they are like," and they buy them for freight service, the least risk, because in various reports made here in the Master Mechanics' Convention, and in this individual report, they see it stated that compound locomotives are more suitable for freight service than they are for passenger service. They find these locomotives are more suitable for freight service than any locomotive that they operate. It is commented upon by the Society of Engineers. Other builders are invited to attend. Additional locomotives are ordered for passenger service with the express stipulation that no more would be ordered but "We will study these locomotives and we will make use of their best features in our design of locomotives hereafter."

I therefore feel that it is due the builders — not myself, or the Baldwin Locomotive Works — but the builders of locomotives in the United States of America, that we do not say that we are still in the experimental stage with compound locomotives. If we say that, what do we think of a railroad manager who places an order with a locomotive works for 165 compound locomotives of one type for one railroad or of one who orders 60 compound locomotives for another railroad, or 15 for another, or 10 for another, or 22 for another, or 65 for another? I could go on and name the roads that have placed these orders. Now, if we are in the experimental stage on compound locomotives, this is all wrong. We must certainly get rid of the idea that we are still in the experimental stage with compound locomotives.

In Conclusion No. 2, in regard to passenger service, the report says: "Compounds have been in use in freight service longer than in passenger service and there are more in such service, but in recent years there seems to be a disposition to use them also for fast heavy passenger service. The compound is not as well adapted to switching service as the simple engine." To the first line of this conclusion that compound locomotives have been in use in freight service longer than in passenger service I beg to object. The first compound locomotive that was built in this country by the Baldwin Locomotive Works, and about the first I think that was put in service in this country outside of experimental types, in years away ahead of that, was a compound passenger locomotive for the Baltimore & Ohio road. It was not such a locomotive perhaps as we would call an up-to-date locomotive today. But we thought it a good attempt at a passenger locomotive ten years ago. We have been building and advocating the use of compound locomotives for passenger service ever since and it is not necessary for me today to say what four-cylinder compounds are doing in passenger service in the United States and in other countries at this time. The reason why there are more compound locomotives in use in freight service is simply that there is more freight to haul than there are passengers and we have got to have more compound locomotives in freight service than we have in passenger service; but on many of the railroads for which we build compound locomotives the freight power and the passenger power also are compounds, and on the same principle. We of course meet with a peculiar state of affairs; we come to a railroad that won't have compound locomotives for freight service — they are all right for passenger service but they won't do for freight service. We have again the reverse of that — they are all right for freight service but we have no use for them for passenger service. Now if these two opposing parties were to exchange ideas to any great length I am inclined to believe that they would use them both for freight and passenger service. But these are conditions with which I do not care to deal. It is immaterial to me personally what kind of a locomotive is purchased, from a builder's standpoint. We build locomotives to make money. We can make money on simple engines as well as we can on compounds, and sometimes more; because in the past, where we built a simple engine, when it passed through the doors, the superintendent of motive power considered that he was responsible for that locomotive; but when you build a compound locomotive you stay with that child until it is a full-grown or worn-out locomotive, one or the other. (Laughter.)

The "flexible" paragraph, which seems to have caused considerable comment — No. 5 — was perfectly well understood by me. I differ from it, however. I think compound locomotives are just as flexible as simple engines. If the question is raised as to what flexibility may mean, whether it is more sinuous than a simple engine, I cannot answer. I have seen them leave the track and climb over the top of railroad stations and one thing and another, but they met the same fate as simple engines under like circumstances — they were smashed up. But for interchange of locomotives, for pooling them, by a careful system of pooling where there are a large number of compounds, they are as flexible as the simple engine. But you take a division of a road with fifty simple engines and one compound and pool them, the compound will not be nearly so flexible, because she will be a total wreck about half the time. The reason for this is that every engineer on that division has got to be educated in the mysteries of this particular compound engine. If he is told that there are no mysteries connected with it he is sure to hunt for them. It is a curious thing; it is a thing that he has not had anything to do with before, and he must find out all about it. Well, by the time they all find out all about it, the evidence is there to confirm the conclusion of this committee, that that engine is not as flexible as the simple engine.

I might go on and comment upon these other conclusions, but there is nothing in them that I care to take exception to particularly. The most important and the all-important point that I wish to establish is that I am opposed to this convention saying today that compound locomotives are in their experimental stage in this country at this time. (Applause.)

MR. DELANO: Mr. Chairman, I believe the work of this committee is of great value to us, but I think there is so much force in what Mr. Vauclain has said that I hope the committee will reconsider this first conclusion carefully and see if they cannot modify it a little bit in the light of what has been said and what undoubtedly will be said. From the figures given of the number of locomotives in this country it appears there must be between four and five per cent of compounds, but even that is not a fair statement. While the compound locomotive is in an experimental stage on some railroads and has not even reached that stage on many railroads, it hardly can be said to be in an experimental stage on roads that have 25, 50 and even 150 of these locomotives in service and in daily use. Cannot the committee take that fact into consideration and say, for example, that the compound locomotive has met with great favor and is being used by many roads, whereas other roads have been holding back to see what experience the roads using them are having?

I want to ask some questions to draw out information from those who are much better posted on this subject than I am. In the committee's summary of replies, Section 6, I note the statement that there should be no difference in the size of drivers between the compound and the simple engine in the same service. I had rather thought from information I had gathered, and from what I had been told, that there were good arguments in favor of larger drivers in proportion to stroke with compound as compared with simple engines. I believe that slow piston travel is an important thing with all engines; but is there not more argument in favor of slow piston travel with the compound than there is with the simple engine? The road I am with has not many compounds, but we have had extraordinarily satisfactory results with two-cylinder compounds in freight service on low-grade lines. The figures are shown here in the body of the report and represent the average performance of four two-cylinder compounds in freight service. We have also had some four-cylinder compounds in passenger service where they have shown exceptionally good results, and we are so well satisfied with them that we are going to order more.

In Section No. 22 I notice that it is stated that the compound will be an economical engine whatever the price of fuel. I would like to ask the committee, or some of the members who are posted on the subject, if the economy of the compound is really not a function of the price of coal, and if it is a function of the price of coal, whether the argument for a compound is not therefore very much greater where the price of coal is high than where it is low?

In Section No. 23½ it is stated that there is no necessity for a difference in the size of the exhaust nozzle of the compound and that of the simple. I should question that a little for two-cylinder compounds, and it seems to me that in that particular the four-cylinder compound, whether it be of the Vauclain type or the tandem type, will have an advantage over the two-cylinder compound in high-speed work because there is double opportunity of getting rid of the low-pressure steam. But I rather question the conclusion that with a two-cylinder compound the exhaust nozzle should be the same as for a simple engine. The pressure of the steam is less, and I think you would naturally suppose that the aperture through which it must escape must be larger in order to give it an opportunity to relieve itself at the same speed.

MR. DEEMS: I might attempt to answer Mr. Delano in regard to Question 6, as to the size of the driving wheel. I want to say in the first place that, of course, this report is just as was stated in one of the reports yesterday — it is entirely impersonal, based wholly on the replies received to the circular, and the replies to Question No. 6 show that fifteen report that there is no difference in size between the drivers of the compound and those of a similar simple engine. One reports that the drivers of the compound are slightly larger both for freight and passenger service.

Question No. 22 is: "Might not the ratio between increased cost of maintenance and decreased cost of fuel consumption make the compound an economical or uneconomical machine as the cost of fuel is high or low in different localities?" Ten replies state that the compound is always economical and can be so used whatever the cost of coal, one stating that with the compound a cheaper fuel can be used and another that the compound, while always showing a saving in fuel, could be used to the best advantage where the cost of fuel is high. I believe that in one of the conclusions it is brought out that it is a more economical engine where fuel is high. So that there is quite a decided majority of the opinion that it is an economical machine whether the fuel be high or low.

As to Question 23½, the question there was: "Is there any difference between size of exhaust nozzle of compound and simple engines of same power, and in favor of which?" In nine cases no difference in size of the nozzle is made, and in five the difference is in favor of the compound. In one or two instances the nozzle of the compound was reduced in diameter to improve steaming of engines.

In regard to what Mr. Delano and Mr. Vauclain have said relative to Conclusion No. 1, I would say there was quite a good deal of discussion relative to that conclusion, and it was realized that the language might be misinterpreted, or rather that it might be given a coloring that would be to the disadvantage of the locomotive manufacturers in this country, and the committee certainly could have no objection — at least I answer for the chairman of the committee, and I believe the others would agree — to altering the language of it; but I think if any one will take the trouble to read all the replies received he would say without hesitation that the conclusion is based strictly on the replies as received. But the information that Mr. Vauclain has given is of course information that the committee did not have and could not be influenced by it. It is something recent, something that has come up since the report was prepared, and it might have influenced the committee very materially.

Professor Goss: Mr. President, I want to commend this report. It shows excellent work on the part of the committee and I have enjoyed it all, especially the bibliography which is presented near its close. There is a sense in which we may say that all modern locomotives are experimental. For six or eight years past we have been in the process of moving on in locomotive design from weights of 100,000 to weights of 250,000 pounds, and such a process necessarily involves a considerable amount of experimentation. It is quite likely that the problems which are thus presented in connection with the simple engines are as difficult and involve quite as much uncertainty as the problems which are presented in connection with the compounding features of a proposed compound engine. I think that there can be no question but that some types of compounds are as well advanced through the experimental stage of design as some classes of simple engines which have recently appeared, and for this reason the committee should give the compound an even chance with the simple. In this connection I am prompted to say that a rather careful study of foreign locomotives leads me to believe that the compound locomotive, as it exists in this country, is a more perfect machine than can be found elsewhere. It is likely that in Russia and, possibly, in France, there is a higher appreciation as to the advantages to be derived from compounding; but in the practice of designing and building compound locomotives which will work economically and will keep the road, it is my opinion that the

United States leads. I would call the attention of the committee to the fact that they have omitted from their classification, on page 3, two classes of engines which are perhaps worthy of their attention. I refer to the Mallet four-cylinder compound having four cranks, and to the compound of the Northern Railroad of France, also of the four-cylinder and four-crank class.

MR. R. H. JOHNSON: Noticing that considerable emphasis was placed on the phrase " experimental stage " quoted by the gentleman, I would say this much, that the experimental stage depends pretty much upon ourselves. I am free to say that I would answer the committee that we were in an experimental stage, from the fact, as you know, that all the lines are equipped pretty well with old engines. Now, if you are allowed to purchase new engines, the management would possibly allow you only ten or twelve compounds. Perhaps out of 100 or 150 engineers you have ten or fifteen men who will take time and have pride enough to study that engine in all its details and handle it efficiently. Now, if the manager asks you what you would like, you would say you would prefer something like what you already possess. Why? Because your men entirely understand their advantages and disadvantages, how to take care of them and get the best results. If I were asked what I would prefer, to equip a new road, then, I assure you, gentlemen, I would say compounds for both freight and passenger service.

MR. WEST: I did not understand from Mr. Vauclain whether the fifty per cent of the engines built in the last year was the output of one company or the entire output of the country.

MR. VAUCLAIN: I cannot speak of other builders. I am speaking merely of the Baldwin Locomotive Works — that over fifty per cent of the domestic output of our plant would be compound locomotives — American locomotives.

MR. HIGGINS: Conclusion 23 reached by the committee states that more compounds are in use where the fuel is expensive than where it is cheap. I have reason to doubt that statement, and I believe the contrary to be the case. Take the roads in the East that are large users of the compound, such as the Baltimore & Ohio, the Philadelphia & Reading, and the road I am connected with, and I don't know of many roads that get any cheaper coal than we do.

I desire to make a motion to the effect that Conclusion No. 1 on page 16 be omitted from the report.

Mr. Garstang: I second that motion.

Mr. Gibbs: The time is pretty short and I do not intend to take up much ——

The President: There is a question before the house. It has been moved and seconded that Clause No. 1 on page 16 be omitted from this report. Are you ready for the question? As many as favor the motion signify by saying "aye"; contrary "no."

The motion was carried.

Mr. Gibbs: The committee omitted to touch upon one important point, I think; one which makes the use of the compound engine almost a necessity in modern railway service. As is well known, the railroads of this country are engaged at the present time in completely changing their motive power; they are building more and more powerful locomotives both for freight and passenger service. This evolution means that we are approaching the maximum allowable weight on the drivers and the maximum possible boiler capacity, this being limited by the weight on the drivers. Now, if the compound, as has been well demonstrated, can save anywhere from fifteen to twenty per cent in fuel and a corresponding amount in water, it simply means that where the limit of steaming capacity is reached, the use of a compound locomotive allows more work to be obtained from a given weight of engine than in case of a simple engine. I think this point should be taken into consideration in considering the advantages of the compound locomotive. As to compounding for passenger service, previous reports of our committee have indicated that they were doubtful of its utility. In freight service considerable data was obtainable, but in passenger service very little; but today there are a large number of passenger compounds running, and the conclusions derived from freight service are fully borne out in passenger. This is also the verdict abroad, in France and Germany. As mentioned by Professor Goss, the four-cylinder four-crank compound is the standard passenger locomotive on three of the principal French railways.

Mr. Deems: I would call Mr. Gibbs' attention to the fact that on page 2 in the last part of the second paragraph the point is brought out that he mentions. It says: "The heavier a locomotive, the smaller is the relative boiler capacity that can be supplied."

Mr. Gibbs: Yes, I had marked that to speak of and then I neglected to speak of it.

Mr. Atkinson: I would simply say, as it may be of interest to this meeting, that by the end of this season we shall have about 178 compounds on the road with which I am connected.

The President: Mr. Gentry, can we hear from you?

Mr. Gentry: Mr. President, before we had eliminated the most objectionable of the recommendations, I was about to say that I could not say anything except agree with Mr. Vauclain, he having brought attention to the tendency that a clause of that nature might have on American locomotives. I felt satisfied that the national pride of our railroad mechanical men would come to their assistance on that. There are one or two sections here that I do not exactly agree with, that is, that I think are of any considerable consequence. In regard to Recommendation No. 5 on page 16, that we have just discussed, of course, if flexibility there means the ease with which an engine may be swapped from one class of service to another, that is one thing; but as a rule nearly all our mechanical men would understand that expression to mean that a compound engine was necessarily so stiff and rigid that she could not be placed safely in the same service as the simple engine. I am satisfied the experience of everybody who has used compound engines would not bear that out.

Referring to Conclusion No. 11, on the same page: "Manual control of compounding feature is preferable to the automatic," I imagine the committee means that it will be necessary for us to put an additional lever in the cab, probably some quadrant or rack or means of holding it in position. The compound engines we have built in the last few years have been of the very heaviest type of engines we have turned out of the shop, and we have been driven to all sorts of schemes to find room for the firemen and enginemen to get around the boiler head. The boilers were so large in some engines we built lately, and we had to make the cab so wide in order to enable the men to get around that we have had to change the route and ship those engines over a road that has no tunnels on it. We find in using an automatic operating device that we could place it much more conveniently for the engineer, which is very essential. We can put it anywhere we want, which cannot be done with the manual starting device, as a rule. There are so many levers and so many appliances on our boiler-heads now that in an emergency the engineer hardly knows which to grab. I think the more we can leave off of the boiler-head the better, and the smaller and lighter we can make them the better. We have had a two-cylinder compound fitted with an automatic starting device that has just gotten home after a trip of about two years and a half. I have followed it pretty generally all over the country, and so far as I have been able to learn, the only time that we have ever had a bonnet or head off of the intercepting chamber was when we wanted to explain it to some fellow and let him see what it was. As far as any defect occurring or having to make any repairs to it, we have not had to remove it, and we have never found any trouble in starting or stopping when the engineman operated the little valve put there for that purpose. We get rid of a great many parts and we make a neater, better looking device. I cannot see that that recommendation will altogether hold good.

In defense of the report I would say that I think it is one of the very best we ever had submitted. Possibly all of our reports have lacked conclusions and recommendations. The committee have certainly done very well indeed. Mr. Deems has just explained in regard to Conclusion No. 1. I presume it was a matter of lack of thought or foresight to open the report with a paragraph that threw a damper on the whole thing, and if somebody had suggested the matter to the committee, the point would have had its attention. In writing the report the committee, of course, did not have the advantage altogether of those who were on the other side of the question.

I agree with Mr. Vauclain in what he said in his opening remarks, that there is not any doubt in the minds of those who have given the compound engine a thorough trial that it has passed the experimental stage. We are building compounds every day on a ratio that is even very much greater than the builders had any reason to expect. There are fewer compound engines reconverted to simples even where they have been used as experiments. We built some compound engines for a road out in the Northwest; we built four engines; half of them were simple and half compound. The conditions were that after they took the engines there and gave them a good trial in actual service, if they thought it necessary to change those compound engines into simple engines we were to do it. It was not a very great while before we were called on to compound the simple engines. That is the only case on record where we had to do some compounding that we would rather not do; we agreed to do it in order to let them have the advantage of the system, fully realizing that the result would be just what it was — that they would conclude to compound the simple engines.

MR. F. W. DEAN: It is very gratifying to see that the general tenor of the report of the committee is in favor of compound locomotives, and in the discussion that has taken place it has been quite a love-feast — everybody has spoken, in the main, in favor of compound locomotives. I think it would be interesting if we could hear something from people who do not use compound locomotives and have them tell their reasons therefor. They seem to be very quiet. It is of course well known that there are many roads on which there are no compound locomotives, or practically none, and on which there are not likely to be any very soon. If some of the Superintendents of Motive Power who do not wish to have any would give their reasons, I think it would be very instructive to the meeting. I should like to hear from Mr. Waitt.

MR. WAITT: Mr. Chairman, I do not know that I have any special reason to state why the New York Central is not using compound locomotives, except that past experience, before I went with the road, was such that they had a number of compounds and changed them over to simple engines, and there was a general sentiment against them. They also had some compound switchers which were not found entirely satisfactory in operating them as compound engines. The state of the art in compound engines seems to be progressing rapidly and improvements are coming in, and I am sure that from the report of the committee and the discussion today, personally I have received a great deal of light and a very strong temptation to give consideration to the compound locomotive that I have not given before. There are, however, so many types that are presented that one feels when he hears the arguments in favor of either of them —

> " How happy could I be with either,
> Were t'other dear charmer away."

I do not know what the outcome will be, but surely there are very strong arguments presented by the committee's report and in the discussion today for favorable consideration of the compound locomotive.

MR. FOWLER: I would like to ask, in regard to Conclusion No. 11, why the committee state that manual control of the compound feature is preferable to automatic. My observation goes to show that the automatic control would be preferable rather than the manual, on the ground that the automatic feature changes the engine into a compound immediately as the engine starts; but that if it is allowed to work as such, the engineer will work it as a simple engine longer than there is any necessity, with the result that there is a greater consumption of steam, especially if it should be allowed to run for any length of time in that condition, unless the manual control is of such a nature that when a speed of over six to seven miles an hour be reached the consumption of steam is so great that the engine cannot run any faster on account of the exhaust being so throttled that the engine cannot get rid of its steam. Of course, in that case the engineer is obliged to close his manual control and allow the engine to go into compound automatically; but I would like to ask the committee the reason for preferring the manual control.

MR. DEEMS: As stated before, this report is entirely impersonal, and if it had been based on the personal opinions of the members of the committee it might have been quite different. I will read the replies received to that question and the gentlemen will understand. I will read the question and then the replies on page 11. The question is: " Some compounds are built so that under ordinary service conditions the change from simple to compound is effected by automatic intercepting mechanism, while with others it can only be done manually. Which type do you prefer, and give reasons for preference? " The replies are summarized as follows: " The automatic is preferred in three cases, as its use eliminates the chance for abuse by the engineer. Eight prefer manual control of the compounding feature, as by this method the engines start better and are stronger and are more flexible as regards power, thus enabling an engineer to help a heavier train over a ruling grade or prevent stalling under adverse conditions. Two prefer to use the automatic feature in starting, but yet give the engineer power to use the engine simple when emergency demands it." So that you see the majority were decidedly in favor of the manual control.

MR. GENTRY: If we have a suitable automatic device, one that we have implicit confidence in, and know that we can trust, it moves the emergency valve to its given stopping place or seat, and I cannot see but that that is all we want to accomplish. After the valve gets into its position and performs its duty and the engineer needs no further control over it, it makes no difference how many levers he has to pull on, he could not pull another car. They cost more money to put in than the automatic device used by us.

MR. J. E. SAGUE: I have not prepared any discussion of this subject which is worthy of the report. I want to say that I consider the report a very creditable one, and I can say that without any conceit, because I had very little to do with getting it out. I think the chairman deserves a vast amount of credit for the report and I know he has had very little help from at least one member of the committee. The conclusions, I think, the committee would differ upon individually. I think it would be difficult to get five or six men to agree wholly upon the conclusions throughout, where there are so many of them. As a whole, I believe they are thoroughly good.

One or two thoughts occur to me in connection with the subject; for instance, in reference to the manual control of the intercepting valve. I think the wording of the conclusion on this subject is a little unfortunate. As I understand it, the wording of the inquiry was such as to lead members to answer in accordance with their preferences for compounds which can be used either compound or simple at the will of the engineer. I think the preference of the majority of those who have used two-cylinder compounds is in favor of the types which can be operated either simple or compound, and if agreeable to the members I think the committee might be allowed to change the wording of the conclusion accordingly. That would meet the objections which Mr. Gentry has raised.

In regard to the attitude of some of the builders of compound locomotives I would say that I can speak for the Schenectady Locomotive Works to some extent, and say that we favor the compound engine very thoroughly. We have very flattering reports from most of the compounds that we have built within the last six or seven years. We consider that the compound engine is thoroughly out of the experimental stage; not that we cannot improve it, however, as we expect to improve details continually as experience suggests, and we think that ten years hence our compound engine may be materially different from what it is today. Some of the objections raised to compound locomotives at the beginning of their use in this country are interesting reading at this date. For instance, the objection was raised to the two-cylinder compound that the low-pressure cylinder would be too large to be practicable for heavy locomotives. We are now building two-cylinder engines weighing 193,000 pounds total, and in no case have we been seriously limited in the building of two-cylinder engines by any of the railway clearances. I have known cases where men have objected to the size of the low-pressure cylinder where the main crank-pin clearance from the rail was the limiting feature. We do not urge the compound engine in season and out of season; we think it is a subject which the railroad mechanical men should decide for themselves. I think the hesitancy about using compound locomotives that has prevailed on some roads is due to the fact that the officers think the compound locomotive is in a state of development, and that by waiting two or three years they may get a better compound than they can get now. I cannot say that I think this position a sound one, because for heavy freight service at least the compound engine is sufficiently better than the simple at this date.

For passenger service there seems to have been a tendency to decry two-cylinder compounds to some extent. I see nothing in our experience to justify that idea. I think, however, that there are some good reasons why compound engines are less favored for passenger service than for freight service. One reason is that a simple passenger locomotive operates at a better ratio of expansion, a more economical ratio, than a freight locomotive, and therefore there is not the same chance to gain advantage from compounding in passenger service that there is in freight service. This is true of all types of compound locomotives. But in cases where we have built simple passenger locomotives with piston valves and everything the best we knew of, and built the same engine identically with the same driving wheel and the same steam pressure, but with compound cylinders, the final decision has been in favor of the compound locomotive for heavy passenger service. In one case trials were made of two passenger locomotives, one simple and one compound. The indications were that the compound was better for certain heavy divisions where the runs were long and grades continuous and that the simple engine was if anything a little better on some undulating divisions. The result was that we got an order for engines part simple and part compound. Before that order was completed, however, we were asked by the administration if we could not change the entire order to compound passenger locomotives. Unfortunately it was too late to do it at that time.

There is a factor which I think should prevail somewhat in the decision as to the choice of compound locomotives in passenger service, and that is, the weight of reciprocating parts. That is a point that has not been touched upon in this discussion. It is an impossibility to make the reciprocating parts as light on a compound locomotive as it is on a simple locomotive. Now, we have urged for years in these conventions that the reciprocating parts should be reduced to a minimum, and a number of the builders have done all they possibly could; they have strained a point, perhaps, to make pistons, cross-heads and piston rods light, for the purpose of diminishing the effect of the reciprocating counterbalance upon the track, and I think this has been lost sight of somewhat in designing compound locomotives for passenger service. I would like to see the position taken by the engineering departments of railways that their specifications would permit a locomotive in which the dynamic effect on the track must not exceed a certain amount; for example, a locomotive which shall not exceed a load of 25,000 pounds per driving wheel, at sixty miles an hour. To meet that condition we would certainly have to take into account the weight of reciprocating parts. As a rule, now, a locomotive designer is only called upon to balance a locomotive so that it will ride easily. I have known of only two cases in my experience in which the railway has analyzed the effect of reciprocating parts upon the track.

One other point which occurs to me is in regard to the use of compound locomotives among a number of similar simple locomotives. It has been stated that under these conditions the compound occupies an unfortunate position. Our experience has been rather different from that. We recently built a compound locomotive which went into service with a lot of 18-inch simple locomotives, and the results were so favorable with the pooling system that the men tried to get the compound in preference to the simple engine, and the same ratio of saving prevailed that one would expect if the majority of the engines had been compound.

Mr. Garstang: Mr. Chairman, I think it is understood that the hour between eleven and twelve is to be occupied today by a topical discussion, and if all the designers of compound locomotives have had a chance to speak on the present subject, I would move that the discussion be closed and that we take up the topical discussion. (Seconded.)

Mr. J. W. Hill: Before closing, I wish to say a word to do honor to the memory of one of our members who long since joined the silent majority. On page 3 the report says that a gentleman in England first conceived the idea of the four-cylinder compound in 1872. I wish to say that in 1868 or 1869 Myron E. Brown, then Master Mechanic of the Erie shops in Buffalo, changed an eight-wheel engine into a four-cylinder tandem compound. He was assisted, I believe, in that work by a man by the name of Lahey, who was then Mechanical Engineer of the Shepard Iron Works in Buffalo, if I recollect right.

Mr. Garstang's motion was put and carried.

The President: Mr. Vauclain will now open the discussion on the topical subject, " Has the limit of length of tubes two inches in diameter been reached in locomotive practice? "

Mr. Vauclain: Mr. President and Gentlemen of the Master Mechanics' Association: I was invited by Mr. Quayle to open the noon-hour discussion today on the subject of two-inch flues. Mr. Quayle states the matter in this manner, however: " Has the limit of length of tubes two inches in diameter been reached in locomotive practice?" Now, at the time that the recent business prosperity overtook us, I gave up the business of being a prophet and turned in to work to avoid the avalanche of business that had fallen over us. After the prophecies I made in the past concerning the Atlantic type of locomotive, large driving wheels, compound locomotives and the use of the Wooten fire-box, I do not object to entering the field at this time as a prophet in regard to two-inch flues. It is my opinion that we have not yet reached the limit in the use of tubes two inches in diameter. In defense of this position, I wish to give you an idea of how two-inch tubes have grown in the recent past on consolidation locomotives. It is not necessary in order to design a perfectly satisfactory locomotive to use long tubes, but for the Baltimore & Ohio Road two-inch tubes 14 feet 10½ inches, and for the Lehigh Valley Road two-inch flues of 15 feet 1 inch have been used. In ten-wheel engines this growth has been more alarming. For instance, in the use a few years back of ten-wheel engines, our longest two-inch tubes were 13 feet; then they went up to 14 feet. Take the Wabash Railroad, 14 feet 3 inches; ten-wheelers on the Atlantic Coast Line, 14 feet 5 inches; on the Chicago & Great Western, two-inch tubes, 15 feet; on the Fitchburg Railroad, 15 feet 1 inch; on the Chesapeake & Ohio, two-inch tubes, 15 feet; on the Chicago, Milwaukee & St. Paul, two-inch tubes 15 feet; on the Chicago, Rock Island & Pacific, two-inch tubes, 15 feet. But this type of engine does not admit of the longest two-inch tubes that we have used. For instance, take the Atlantic type, we used tubes for the Lehigh Valley originally 15 feet 1 inch. The last Black Diamond express engine delivered to that road had two-inch tubes 15 feet 6 inches; the St. Paul & Duluth, 15 feet; the Central Railroad of New Jersey, 15 feet; the Chicago, Milwaukee & St. Paul, 15 feet; the Erie Railroad, 15 feet, and last but not least the C. B. & Q. with two-inch tubes, 16 feet. Now a 16-foot tube two inches in diameter is a perfectly reasonable and rational thing to use, and why is it? Because our friends on the opposite side of the water have long used two-inch tubes longer than 15 feet, longer than 16 feet. On the Griazi-Tsaritzin Railway, of Russia, we find two-inch tubes 17 feet 5 inches; on the Balaklava Railway, on small locomotives, tubes 15 feet 5 inches, and on some normal types of Russian standard locomotives we have two-inch tubes 18 feet 1 inch. Now, I have no hesitation whatever in making the prophecy that we will find two-inch tubes used in locomotive boilers in the near future 20 feet long. I do not wish to appear unreasonable or flighty, but there is a certain use that the additional length of these tubes can be put to, if the locomotive is properly designed, that will be a decided benefit and advantage to the locomotive. It is not my purpose to show you how to do it, because I think you will all be able soon to show us how to do it. The locomotive builder is usually driven to things of this kind; that is, he likes to be driven to it. He does not like to assume the position of being responsible for using a 16-foot tube or a 17-foot tube unless he has used it before and knows it is all right. But a progressive railway man will come in and say: "I see no objection to using flues 2 inches in diameter, 16 feet long, or 17 feet long"; and when you come to reason the thing out, if you have a tube 15 feet long and your engine does first-class work, are you going to make it forever useless if you add 6 inches to the length of the tubes? Of course, there is a jumping-off place somewhere; we cannot make them 40 feet long; but within the limit of design of the locomotive I think that a two-inch tube can be used up to 20 feet in length, so far as the diameter of the tube is concerned. Now, in regard to the rigidity of the tube, the absence of vibration when it is in the boiler, I think we need not give that any consideration. Tubes are fitted in locomotive boilers 15 feet long and 15 feet 6 inches long. Take certain locomotives we built recently with tubes 16 feet 7¾ inches long — we shipped those locomotives without any water in them. Well, if there is not a splendid opportunity for those tubes to vibrate under those conditions I want to know it. But you put a locomotive in service with the tubes surrounded by water and I think that the jar due to vibration, excessive vibration, is very much reduced. Why do I think that an iron tube two inches in diameter will give no trouble from vibration? Simply because we have used brass tubes, and I might add that the tubes in the foreign locomotives which I mentioned are composition tubes; they are not iron tubes or steel tubes. Some of them are iron tubes with copper ends brazed on. The entire thing depends on the brazing of a six-inch piece on the end of the tube. I doubt if many users of locomotives in this country would care to risk a brazed end on their tubes. There is no danger in using it; there is no risk to run. It would be a novelty, perhaps, with us, but with them it is a thing of long practice and found to work successfully and to be absolutely reliable. Now, if a brass tube two inches in diameter and 15 feet long will give no trouble — or even 16 feet long as we have used them — I can see no objection, so far as vibration is concerned — the damage to the tube, the leaking of the joints — to the use of an iron flue 20 feet long. (Applause.)

Mr. Higgins: Mr. Vauclain referred once or twice to the road I am with, in regard to the use of long flues. I wish to say that in 1896 the Baldwin Locomotive Works built for us five engines of the Atlantic type for passenger service, and we then commenced the use of tubes 15 feet 1 inch in length. We were forced into this on account of the design of the running gear, and I was quite doubtful at the time whether we were right or not. Those engines have been in service since that time and it is very hard service. Some of them double a division that gives them four hundred miles every twenty-four hours, and up to the present time we have had just as good, if not better results, from those long flues, 15 feet 1 inch, than we have had from flues 14 feet to 14 feet 6 inches.

Mr. McIntosh: I will corroborate what Mr. Higgins has said in regard to the service of tubes 15 feet in length. We have a number of engines thus equipped and we do not find any less satisfactory service from that length of flue than we have from shorter ones.

Mr. Henderson: Both the gentlemen who have just spoken use anthracite coal, I believe. Now it is probably not so necessary to have a large flue for anthracite coal as it is for bituminous coal.

Mr. Vauclain spoke of the fact that some 16-foot flues were being used on the C. B. & Q. Railroad. I would like to hear something about them.

With regard to the vibration, we ought to bear in mind that when the flue is submerged the displacement of the water is very nearly equal to the weight of the flue itself; that the flue is almost entirely supported throughout its whole length, so that there is probably not very much chance of vibration on that account.

Mr. Delano: The C. B. & Q. has been making some experiments for some time to determine how much they could diminish the diameter of the tubes or lengthen them, and a number of years ago it was found that two-inch tubes, 12½ feet long, in mogul locomotives did very much better than tubes 2¼ inches in diameter—gave less trouble from leakage, and less trouble from stopping up. Within the last year the thought naturally occurred to us that we might carry the experiment even further, and we have tried a locomotive of the same class with 1¾-inch tubes, 12½ feet long. The experiment resulted so satisfactorily and the engine appeared from all accounts to be so noticeably better than other engines of the same class, that in getting up designs for a new engine we carried out the same ratio, or very nearly the same ratio, of diameter of tube to length of tube which we had in the 1¾-inch, 12½-foot tubes, and in some new engines with 16-foot flues we are going to use two-inch tubes. I cannot say that we have had these 16-foot tubes two inches in diameter long enough to really know how they are going to serve us, but we have had 16-foot tubes 2¼ inches in diameter over a year and we have not had any trouble from their pulling through the sheets; no trouble of that kind at all. I cannot see that reducing the diameter would increase that trouble, and our experience with 1¾-inch tubes shows that we have no more trouble from their stopping up. My theory of the thing is that it is a good deal like the case of a drain-tile stopping up — that the smaller the diameter within limits the less danger there is of stoppage. I should like to hear from some of the gentlemen as to what they have arrived at as the limit, the minimum limit for diameter, because, as I take it, the ratio of the diameter of the tube to the length is an important factor; at any rate, the foreign engineers take account of it in their designing. If for any reason the distance between the tube sheets is short, they reduce the diameter of tubes in proportion. It has seemed to me in this connection that one of two things ought to be done; either that the tube must be made large enough in diameter so that the flame will not be cooled down below the point of ignition in passing through the tube, or else it must be made so small, down to the limit of smallness, that the heat of the gases would be extracted in passing through. Another point which has a bearing on the subject is, that with the smaller tubes I think you can safely use a smaller gauge, a thinner gauge of metal in the tube, therefore getting the gases a little nearer the water.

Mr. McIntosh: I would like to ask Mr. Vauclain if he would not consider it necessary to increase the number of tubes in a boiler proportionately to their length, otherwise, in my opinion, the movement of gases would be restricted.

Mr. Vauclain: In answer to Mr. McIntosh's question, I do not think that would be necessary at all. We always increase the number of tubes in proportion to their diameter in order to get equivalent heating surface. The smaller the diameter of the tube the greater the heating surface we can get in a given boiler. The length of the tube is determined merely by the liability of the tube to stop up, and not from any danger that there might be from leaking. We have found no danger whatever from leaking in long tubes or any serious detriment to the life of the tube. Tubes 15 feet long in Atlantic type engines delivered in 1894 and 1895 were removed last month, so that vibration did not affect them nor did the length of the tube cause any trouble, as they were excellent steamers.

I wish to state in addition to my answer to Mr. McIntosh's question that we have used 1½-inch tubes 10 feet 4 inches long on hundreds of locomotives and we would have no hesitation whatever in using 1¾-inch tubes 12 feet or up to 15 feet. We have used 1¼-inch tubes 13 feet 6 inches already.

Mr. Brown: I would like to hear from some of the members about what they think the diameter of the flues should be. I would state that, in my younger days, I was for a number of years connected with an English road, and the practice at that time, and I believe it is so now, was that the 1¾-inch flue was generally used. It was a brass flue. In fact, I never saw any iron flues there at that time. The flue was rolled thicker at one end than the other — one gauge thicker — and the thick end was put next the fire-box. The lengths at that time were not what they are at the present day and consequently we had very little trouble with them. I think the two-inch flue is the ideal flue, especially where you use anthracite coal, because the smaller the flue the more readily it is stopped when the draft is very strong, and consequently the fine ashes and dust are pulled through the flues a great deal more with engines using anthracite fuel. If we use the 2¼-inch flue we naturally reduce our heating surface, which is not a good feature. As regards the length of flues, Mr. Vauclain has enlightened us very much. I had no idea that we had such lengths in service. I know that we have very little trouble with the short flues, and I think we must expect trouble with the long ones, for the reason that when you are lighting a fire and everything else is comparatively cold, the heat goes through the flues and they naturally get more heat in proportion than the rest of the boiler, which will throw strains on the flue sheet and give us trouble. There is no doubt that we have not yet reached the limit of the length of flue. I think the two-inch flue is the ideal flue.

MR. ANGUS SINCLAIR: I think it is very fortunate that this question has come up for discussion at this time. The matter of the proper length of flues has been, at various times, very thoroughly investigated by foreign engineers, and from their conclusions the railway world appeared to have settled down to the belief that the proper length of a two-inch tube was from 12 to 14 feet. Since the experiments were carried out from which these conclusions have been drawn, there have been great changes effected in the conditions of boiler operating. The pressure has been greatly increased, consequently the temperature of the boiler has been increased and the combustion per foot of grate area has become very intense, resulting in a very high fire-box temperature.

A series of very careful experiments were made by a French engineer in which the boiler was divided up into sections, and it was found that beyond a certain length the forward section was of no value to speak of as a heating surface, and its tendency was to make the tubes choke up through its greater length; consequently, it was believed to be a better practice to cut off that length so that the draft would be freer. But now the temperature has increased so greatly that this front section which, under 120 pounds pressure of steam, was no use for steam-making purposes, is of great service now, and consequently the direct line of progress is to increase the length of the tube until it is found out how long it can be made economically. I do not think there is any difficulty so far as the drawing out of the flue sheet on account of its increased length, or strains that would cause leakage is concerned; but it seems to me very important that American railroad companies now, with the revolution in boiler pressure, should find out just how long a tube should be made to do its work economically.

MR. ROBERT QUAYLE: I do not think I can add very much to what has already been said, but this thought has occurred to me, that in our topical discussion, if the subject is well started it is well ended, and I think that our good friend, Brother Vauclain, here, started that so well that he excited an interest in the subject in every one present. Being chairman of the Committee on Topical Discussions, I might say that the question came to me through the designing of a new locomotive. We have a good many locomotives on our line that have tubes 15 feet 2 inches in length, and they have never given us any trouble in any particular except when they were shipped first from the locomotive works to us without water in the boiler. We found that they gave us trouble in leaking, and discovering that, we first thought it was due to workmanship, but on thorough investigation we found that was all right. Then we asked them to ship the next to us with the flues covered with water. That stopped the trouble, and we had no more leakage after that. Those engines have been in service some years and they give us no more trouble from stopping up or from leakage than any other engines. Therefore I arrived at the conclusion to build the locomotives we are getting now with 16-foot tubes, and I think that others have determined perhaps that they will go us one better very shortly. I think we are having less trouble today — it may be from better care of our boilers and tubes — but I think we are having less trouble today on most of the trunk lines from leaky flues than we ever had before, and I think, too, it is a fact that we have got longer tubes than we ever had before. I think, therefore, we have not reached the length of the tube yet, and I am very glad to hear so many hearty supporters of that proposition here this morning.

MR. GEORGE L. FOWLER: I would like to emphasize what Mr. Sinclair said a moment ago in regard to experiments which were conducted in France, I think, some time ago, in regard to the availability of the front ends of the tubes as a steam-producing section of the locomotive. My recollection of the experiments is that, as Mr. Sinclair said, they took the temperatures at different sections along the tube. They found at the front end of the tube that the temperature of the gases, as they passed through, suffered very little diminution—I have forgotten the figures, but it was very slight. However, they came to the conclusion that the increase in the length of the tube beyond the length decided on was practically of no value as a steam-generating surface.

I would have to differ from Mr. Sinclair in regard to the reason for lengthening the tube because we have increased the temperature of the boiler. If you increase the temperature of water in the boiler, then of course its power of abstracting the heat from the tube grows less as the temperature of the gases falls, and I think that before the length of the tube is increased to 20 feet or more it would be well to conduct a careful series of experiments to determine as to whether the front ends of those tubes are of any value whatever as steam-generating surfaces; because, if you reduce the temperature of your gases down to the smoke-box temperature three feet before they reach the end of the tube, those three feet are absolutely of no value whatever for generating steam, and that is a point on which I think no experiments have ever been conducted in this country, and only a very few, and only in one instance, abroad.

MR. GEORGE GIBBS: In speaking of these foreign equipments, it should be remembered that they were on stationary boilers, and with low rates of evaporation and amounts of coal burned per square foot of grate, and are consequently not really applicable to American practice in locomotive boiler construction.

MR. DELANO: To answer one of the last speakers I want to say, that in the engine we tried with 1¾-inch flues, we found that the increased heating surface of about ten per cent which we obtained, enabled us to increase the size of our nozzle-tip about a quarter of an inch, hence we assume that the gain came largely from that source, the gases passing through the tubes at a lower rate of speed due to a smaller vacuum in the front end.

MR. F. M. WHYTE: I would like to remark that until the smoke-box temperatures are reduced considerably below what they are at present it will not be necessary to cut off any of the front ends of the tubes.

On motion the discussion was closed.

THE PRESIDENT: The next topical discussion is "Metal versus Wooden Cabs for Locomotives." Mr. Sague.

MR. J. E. SAGUE: The relative advantages of wood or metal cabs have been considered by all mechanical officers and locomotive designers, and it probably appears to many that the future development of American locomotives will involve a much more extensive use of steel cabs, conforming to the almost universal practice in foreign countries. Considerable can be said on both sides of this question. In favor of metal cabs, the increased strength and durability and the lower cost of maintenance might be urged; against them, the greater first cost and increased weight.

Steel cabs are standard on all Southern Pacific lines, and their mechanical engineer, Mr. F. W. Mahl, advises me as follows: "The first steel cab was built in 1891 for the Southern Pacific system in Arizona. In July, 1895, nothing had been expended for repairs. Since 1895 no wood cabs have been built. In 1895 a number of 22 by 26-inch mountain locomotives were built with steel cabs. Nothing has been expended on them for repairs. It is reported that the paint on metal cabs lasts longer than on wood. The Southern Pacific cabs are lined and have double roofs and are said by engineers and firemen to be as cool as wooden ones."

Against steel cabs are increased first cost and increased weight. At present prices of material, the average steel cab will cost from $90 to $100 more than wood. This increase in first cost is probably justified, however, in view of the saving in maintenance. The increased weight is a more serious feature. Comparing the weights of average designs roughly, shows for small metal cabs 900 pounds increase and for large cabs 1,300 pounds. Some special designs have been made which show 1,500 pounds increase or more. It should be said that if you want to make a good looking job of a steel cab it needs to be made rather heavy. The increased weight prohibits the use of steel cabs on some new designs where all possible must be done to save weight on the back end of the locomotive. This applies especially to engines in which the driving-wheel weights are limited and in which the maximum boiler power is necessary. It will apply to many recent designs of large passenger engines, examples of which will readily occur to all. In other types, the extra weight of steel cabs may improve the distribution of weight. Many cases will occur in which increased weight is allowable in repairs where not justified in original construction. Steel cabs might thus be permissible in renewals, as the bridges and tracks become strengthened, or as the track department becomes less conservative. Steel cabs are almost essential in hot and dry climates or where alternate moisture and dryness are destructive to wood.

MR. MCINTOSH: The road with which I am connected has used for some years past a combination cab, lined up with steel on the outside and wood frame on the inside, which seems to be very serviceable and presents a very good appearance when painted. We are now making some experiments with wood pulp board for cab roofing and I fancy we may produce a combination cab of wood pulp and steel that will be both light and very serviceable.

MR. G. R. HENDERSON: Some time ago when I was down on the Norfolk & Western Road we had a great deal of trouble with wooden cabs on freight engines on account of their racking very badly; and in a short time, no matter how carefully we braced them, they would seem to go to pieces — get loose at all the joints — and we started in one time and made a cast-iron front for the cab. It was made as light as possible and bolted to the boiler just back of the dome, forming the front of the cab, and went up in between the two windows up to the roof. That was quite an advantage. The rest of the cab was wood, but it gave us something very solid to bolt the cab to. Later on we got some sheet steel cabs, and talking to Mr. Lewis this morning, he told me that they had been very satisfactory. I know the Norfolk & Western Road has had some for several years, and if Mr. Lewis is here he can possibly give us some points as to how they compare with wooden cabs.

MR. QUAYLE: I might say that I believe that locomotive engineers now are trying to get rid of all the extra weight they can, and all the cast iron they used to put in the cab they are getting out and putting into the boiler, or the weight of the cast iron

The motion was carried.

THE PRESIDENT: The Secretary will cast the vote of this Association for Mr. Miles.

THE SECRETARY: Mr. President, the vote of the Association has been cast for Mr. Miles as an honorary member.

I have a further report from the Executive Committee.

To the Members of the American Railway Master Mechanics' Association:

The question of the admission of honorary members to the Association which was referred by the Association to the Executive Committee at yesterday's session, was taken up by the committee, and it was considered right and proper that this matter should be referred to the committee which has been appointed to take up the revision of the Constitution. The committee would, therefore, recommend that a clause be inserted in the recommendation of the committee covering the honorary membership, and that no action be taken on the recommendation regarding Messrs. H. Elliott, J. L. Greatsinger, Robert Miller and R. C. Blackall until such revision is made.

THE PRESIDENT: Gentlemen, what is your pleasure with the report?

MR. VAUCLAIN: I move that the report be adopted.

THE PRESIDENT: It is moved and seconded that the report of the Executive Committee be adopted.

The motion was carried.

The Secretary read the following report:

REPORT OF COMMITTEE APPOINTED TO SUGGEST REVISION OF CONSTITUTION, TO CONSIDER THE SUGGESTIONS OF THE COMMITTEE ON: "WHAT CAN THE MASTER MECHANICS' ASSOCIATION DO TO INCREASE ITS USEFULNESS?"

To the President and Members of the
American Railway Master Mechanics' Association:

Your committee was appointed in accordance with the following resolution:

Resolved, That a committee be appointed to consider the suggestions made in this report and present later in this convention recommendations for such changes in the Constitution as may be necessary to carry them into effect. Your committee would respectfully suggest changes in the Constitution and By-laws under the following headings:

Nominating Committee:

In Article VIII, Section 1, line 2, after the words " shall be," insert the words, " Nominated by a committee of three appointed by the president and "; omitting the words " separately without nomination."

Admission of associate members:

That the word " letter," should be introduced before the word " ballot " in the eighth line of Article III, Section 2.

Article III, Section 5, add in the first line the words " active or associate " after the word "Association." Also add the following sentence: " The nominations must be made by the Executive Committee " after the word " members."

Individual papers:

In Section III, Article 9, add the words: " Individuals or " after the word " appoint," in the last line on page 10, and omit the word " special " in that line. Also add to this paragraph the words: " Or individual papers may be presented to the Association after approval by the Executive Committee." After that, add the following: " Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading, unless otherwise ordered by the Association."

BY-LAWS.

Add under the head of Order of Business, a new line, No. 6: "Appointment of Nominating Committee," and change the numbers of the subsequent lines.

Add to paragraph 9 of the By-laws, the following words: "And no member shall have the floor for more than five minutes at a time unless otherwise ordered."

RESOLUTIONS.

Your committee respectfully offers the following resolutions:

Resolved, That the president shall appoint a committee to investigate and report next year upon the advisability of this Association taking membership in the American Section of the International Association for Testing Materials.

Resolved, That it is the sense of this Association that a joint library should be established by the Master Mechanics' and Master Car Builders' Associations; and it is further

Resolved, That a committee be appointed to report upon the subject next year, and also that the Executive Committee invite joint action with the Master Car Builders' Association.

Your committee respectfully recommends that the secretary be instructed to use marginal captions in printing the reports and papers in the proceedings.

Your committee would also respectfully recommend discussion and adoption of the suggestions contained in the report under the following headings:

Discussions.
Selection of Committees.
Railroad Clubs.
Instructions to Committees.
Subjects.
Committee on Subjects.
Topical Discussions.

R. QUAYLE,
H. A. GILLIS,
S. M. VAUCLAIN,
Committee.

SARATOGA, June 21, 1900.

THE PRESIDENT: Gentlemen, you have heard the report of the committee. What is your pleasure?

A MEMBER: I move its adoption.

MR. HENDERSON: Before a vote is taken on its adoption I would like to offer an amendment to the second clause and that is, that honorary members be voted for by letter ballot the same as associate members.

THE PRESIDENT: It has been moved and seconded that the report of the committee be adopted. Are you ready for the question? Now, Mr. Henderson, did you wish to put that in the form of a motion?

MR. HENDERSON: I put that in the form of an amendment to the resolution as offered by the committee — that after associate membership the words "honorary membership" be added, so that the letter ballot will include both honorary and associate membership.

MR. GILLIS: I was of the same opinion as Mr. Henderson when I first discussed the question in committee, but I am firmly convinced that I was wrong and that the recommendation of the committee is right. I am confident, had Mr. Henderson heard the arguments of the other members of the committee he would agree with the recommendation.

PROFESSOR GOSS: Before a vote is taken may I ask what is the effect of the adoption of this resolution or this motion? Does the adoption of this motion constitute an amendment to the Constitution?

THE PRESIDENT: No, sir; it will be necessary that a resolution be presented to the Association to the effect that the Constitution be changed at its next meeting. There is no resolution offered by the committee to that effect.

PROFESSOR GOSS: That gives me the information I wanted.

THE PRESIDENT: They make these as suggestions but do not offer them as a resolution.

MR. DELANO: If Mr. Henderson's motion has not got a second I would move as an amendment to the motion before the house that the changes in the Constitution and By-Laws recommended by the committee be submitted to the membership in the proper way and at the proper time for a vote.

MR. GIBBS: I second the motion.

MR. GILLIS: As I understood the original resolution the committee was given power to make such changes as were necessary in the Constitution to carry out the wishes of the members.

THE PRESIDENT: You understand, gentlemen, that no action can be taken on the change in the Constitution until next year.

MR. QUAYLE: As I understand the motion of Mr. Delano it is right to the point, and we discussed that the other day in meeting. I would ask that the Secretary now read the articles as amended or changed and present them to the Association so that they may know how it will read when this action has been taken upon it. We did not recommend that, but we expected that it would come before the Association.

MR. DELANO: I understand that this cannot be voted on today, but it can be submitted to a vote of the membership. I do not think we have to wait until next year's annual meeting.

THE SECRETARY: The Constitution says in regard to amendments: " This Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendment has been given at a previous meeting at least six months before."

MR. VAUCLAIN: In defense of the recommendations of the committee and in order to straighten out this slight tangle I wish to say the following: Mr. Gillis, as already stated, has the same view as Mr. Henderson entertains, that the election should be by letter ballot; but after considerable argument in committee it was agreed that any reputable member of this Association, a man who had spent years in service might be sacrificed by the letter ballot system; for instance, if letter ballots were distributed to various members of the Association, the man to be voted for might be unknown to a good many of the members, especially the younger members, and it might depend somewhat as to what frame of mind they were in, as to whether they would vote yes or no. We further considered that an election to honorary membership was of sufficient importance to come before us in our annual convention, so that we would have the honor of electing these gentlemen to this position at that time, not in a perfunctory manner by letter ballot. The criticism in the *Railway Age* this morning upon certain things that have passed in this Association would lead me to believe that the conclusion that we arrived at was a wise one, that we should at least leave something for the Association to do when we assemble here in convention. Now if I were to recommend a method of procedure it would be that the Secretary be authorized to print the Constitution and By-Laws as they stand now upon one half of the page and opposite the sections as they would be changed if the recommendations of the committee were adopted, so that the members can have it in good shape before them at the next annual meeting to vote either for the adoption or the rejection.

THE PRESIDENT: Mr. Henderson, do you still insist on your amendment?

MR. HENDERSON: No, sir; I withdraw it.

THE PRESIDENT: The question is on the adoption of the report of the committee. As many as favor the adoption of the report will signify it by saying " aye "; contrary " no."

The motion was carried.

MR. SEELEY: I wish to call attention to the fact that the language of our President in regard to the honorary member just elected was a little indefinite. As I understand it he offered his resignation and the convention offered him honorary membership.

I think the language of the President made it appear that he applied for honorary membership.

THE SECRETARY: The letter of Mr. Miles was read yesterday in convention. The matter was referred back to the Executive Committee and it recommended to the Association that Mr. Miles be made an honorary member.

MR. SEELEY: That is exactly as I understand it. I merely referred to the inadvertency in putting the motion that the gentleman had applied for honorary membership.

MR. VAUCLAIN: I now wish to make a motion that the Secretary be authorized to print the Constitution as it now stands and also the Constitution as it will stand amended if the recommendations of the committee be adopted, for presentation before the members at the next annual meeting.

THE PRESIDENT: You have heard the motion. Are you ready for the question? As many as favor it will signify by saying "aye"; opposed "no."

The motion was carried.

THE PRESIDENT: Gentlemen, as it is nearly half-past twelve, and it was decided yesterday that we should adjourn at that hour today, a motion to adjourn would now be in order.

On motion the convention adjourned until the following day.

THIRD DAY'S PROCEEDINGS.

The convention was called to order on Saturday, June 23, at 9:10 A.M.

THE PRESIDENT: Gentlemen, please come to order and we will now proceed to business.

THE SECRETARY: Mr. President, I have the following proposal to read:

> We, the undersigned, propose the name of Mr. John Player, of Dunkirk, New York, for associate membership. (Signed)
>
> JAMES MCNAUGHTON.
> PETER H. PECK.
> WILLIAM GARSTANG.

This report will be taken up for action one year hence, the President in the meantime naming the usual committee of investigation.

MR. MILLER: I move you that the recommendation of the committee be accepted and that Mr. Player be made a member of the Association.

THE PRESIDENT: Mr. Miller, it has been customary to refer these applications to a committee to be appointed by the President, which committee shall report to the Executive Committee on the fitness of the applicant to become a member. The Executive Committee will then report on the matter at the next meeting. That is in accordance with the Constitution, and I will appoint as the committee of investigation Messrs. A. E. Miller, W. H. Marshall and A. E. Mitchell. The first order of business this morning is the report of the Committee on Journal Bearings, Cylinder Metals and Lubrication.

MR. W. C. DALLAS: Your committee appointed on this subject was somewhat late in getting to work on account of the delay in getting a new chairman. After meeting we sent out a circular of twelve questions and the replies that we received to those questions were rather limited. After looking the replies over we found that it would be impossible to make specific recommendations on all the points raised, but I give below the deductions of the committee from the replies received to the various questions asked:

1.—Best cylinder mixture for high-pressure engines.

It is impossible for your committee to derive any positive deduction or make any special recommendation owing to the variety of metals in use.

2.—Advantages in casting cylinder saddles separate from the cylinders.

The deduction of the committee from the replies to this question would be that cylinders and saddles in one piece can be so designed, molded and handled in the foundry as to give perfect satisfaction and still be so secured to the frames as to be immovable, resulting in economy, not only as to first cost, but in cost of maintenance, although one road has been for the last two years using the three-piece cylinders and saddles, and from observations made at different times it seems they are having great success not only in keeping the cylinders secured, but they have been able to reduce to a minimum the time in which to apply a new cylinder. The method pursued by this road allows a different metal to be used in the cylinders than that in the saddle; plainly speaking, a hard metal can be used in the cylinders and a softer metal in the saddles. This arrangement seems to have advantages over the two-piece cylinder and saddle. The method of fastening is shown on pages 278 to 280.

3.—Trouble with cylinder saddles breaking when cast in pairs.—No deduction.

4.—Preference and use of solid piston heads.

It is the opinion of the committee that extraneous circumstances would have a tendency to control the use of solid pistons. For instance, a road where considerable drifting is done might have extraordinary cylinder wear with solid pistons without ready means of regulating unless continuous piston rod should be used, in which case but little difficulty should be experienced and a much more safe and economical solid piston used. Again, other roads where very little drifting is done and steam used in the cylinder constantly, very little trouble should be experienced with solid pistons, especially where high pressures are used.

The committee is also of the opinion that those roads using

20-inch and over cylinders will of necessity be compelled to use solid pistons, and of steel, in order to secure the requisite strength and keep within the desired weight limit of piston. It is also questionable whether it will cost any more, with modern machinery, to renew an entire solid piston head than it would to renew bull rings with consequent facing of spider, follower plates and refitting of follower bolts.

5.—Cylinder wear — solid piston heads compared with bull ring type.

The committee is inclined to believe that, leaving out of the question drifting, imperfect lubrication, etc., the question of cylinder wear depends upon piston size and weight. The heavier the piston the more rapid the wear in the cylinder and piston. No reason can be seen why, under the same circumstances, the solid and built up pistons should not wear uniformly, and as the solid piston made of steel can be made much lighter for equal strength, its use would seem to tend toward diminished cylinder wear.

6.—Metal mixture in piston heads and packing rings.

It would seem to the committee that the proper method of securing correct metal for piston packing and bull rings would be by making the tests upon a chemical analysis basis, but the committee has no data from which to make any recommendations. It would seem to be reasonable that, with proper lubrication, much better results would be secured by using a hard metal rather than a soft one. Many roads have increased the life of their packing rings very materially, and also noticeably saved cylinder wear, by turning a groove in center of outside of packing ring about 3-16 inch deep and covering one-third of the width of the ring, the explanation being that each ring carries its lubrication with it in this groove in the shape of moist steam, which more than offsets the diminished bearing surface liability to increase the wear.

7.—Wear of piston heads.

While nothing was contained in the replies, it would seem that the depth of the packing rings would have an important bearing on the allowable wear, the presumption being that those roads having the larger limit use a deeper ring than those whose limit is considerably smaller.

8.—Diameter of packing rings above cylinders.

As a comment, it would seem that the increased diameter of packing rings over cylinder should logically bear a certain relation to cylinder diameter, and that one or the other of the latter two methods would give more uniform results. Here again, however, we run against the quality of the iron in the rings as to elasticity and ability to retain it, consequently no rule can be deduced that would be suitable under all circumstances with this variable quantity entering in as a factor.

9.—Alloy for bearing metals.

The question of proper bearing metal for heavy fast passenger service is an important one, but it would seem from the various replies received, each one having good success with their own mixtures, that it is a question for each road to decide, after taking into due consideration design of engine, weight on square inch of bearing surface, road bed and ballast conditions, methods of oiling and quality of lubricant used.

10.—Use of soft metal in connection with bearing metals.

Undoubtedly one of the best metals for locomotive bearings and connecting rod boxes is what is known as "phosphor-bronze," "S" grade. It is recommended by this committee that a fair price be paid or allowed for bearing metal, then demanding first-class material. For illustration, bearing metal at 10 cents per pound giving trouble heating does cost a company more money than bearing metal at 16 cents giving no trouble, if quality is demanded when 16 cents is paid for it. It seems that bearing metal should be based on mileage, giving cost per 1,000 miles, and not by cost per pound alone. Some roads keep their figures as per paper attached, which shows conclusively if bearing metals are giving good results and that lubrication is perfect.

The committee would state that no matter what the mixture may be, foundry practice assumes almost as important a part as the mixture, to prevent hot bearings, and should be given careful consideration.

11.—Lubrication of cylinders, valves, etc.

Commenting on the replies to this question, it is the opinion of the members of this committee that with the modern lubricator, properly applied and operated, very little difficulty should be encountered in securing proper lubrication to valves and pistons, providing a proper lubricant and sufficient of it is used.

12.—Best method of locating holes, oil grooves and oil pockets in driving boxes.

The committee has no recommendations to make but gives illustrations of various methods employed.

The report is as follows:

REPORT OF THE COMMITTEE ON JOURNAL BEARINGS, CYLINDER METALS AND LUBRICATION.

To the President and Members of the
American Railway Master Mechanics' Association:

Your committee appointed to investigate and report on the above subject has been very much disappointed at the limited number of replies to its circular letter of inquiry, and to those of the members who have replied and given the benefit of their experience the committee desires to express its thanks.

Your committee sent out a circular embodying twelve questions which, in its opinion, would cover, in a general way, the subject it was appointed to investigate, and as it is impossible to tabulate the replies in a condensed form, it is decided to take up each question separately, give a summary of the replies and the committee's comments on them, with its own experiences.

Cylinder met
mixtures for
high-pressure
engines.

Question 1. Please give the committee what you consider the best cylinder mixture for your heaviest high-pressure engines.

The replies to the question can be arranged in three groups. The first group containing the largest number of replies is from roads which do not operate their own foundries, and they give the uniform specifications, a close-grained iron as hard as can conveniently be machined and prevent castings being subject to shrinkage cracks.

In the second group we have those who operate their own foundries or who purchase cylinders on guarantee to meet specific composition, such specifications calling for various grades of new iron and scrap.

In the third group we have those who have advanced a step farther and added to their specifications the use of a varying percentage of steel scrap with their iron constituents.

The following is a detailed list of the roads replying in second group, who use a specific composition, with the kinds and percentages of iron used:

SOUTHERN PACIFIC COMPANY.

No. 1 pig iron	20 per cent.
No. 2 pig iron	13 per cent.
Selected scrap	33 per cent.
Old wheels	34 per cent.
Magnesia	10 pounds.

Chicago, Milwaukee & St. Paul R'y.

No. 3 Salisbury iron	20 per cent.
No. 2 Shelby iron	5 per cent.
No. 2 Heckla iron	20 per cent.
No. 4 Eagle iron	5 per cent.
Old car wheels	50 per cent.

Oregon Short Line.

No. 2 foundry coke pig iron	20 per cent.
No. 2 charcoal coke pig iron	10 per cent.
Old car wheels	10 per cent.
No. 2 scrap	40 per cent.
No. 1 select scrap	20 per cent.

Canadian Pacific Railway.

Wheel scrap	70 per cent.
Ordinary good scrap	15 per cent.
Silicon pig iron	15 per cent.

Chicago, Rock Island & Pacific R'y.

2-3 Rock Run charcoal pig iron.
1-3 old car wheels.

The Rock Run being procured from a mine of that name in Alabama, the design being to get them as hard as they can be and allow of machining.

Duluth Shore & Atlantic R'y.

No. 1 iron	40 per cent.
No. 3 iron	35 per cent.
Selected scrap	25 per cent.

Grand Trunk Railway.

Pig iron	20 per cent.
Old car wheels	20 per cent.
Ordinary cast scrap	60 per cent.

Erie Railroad Company.

No. 1 pig iron	50 per cent.
Machine or loco. scrap	50 per cent.

Excluding all car scrap.

Baltimore & Ohio Southwestern.

Charcoal pig iron	31 per cent.
Car wheel scrap	31 per cent.
Soft scrap	38 per cent.

Ferro Carriles del Sur del Peru.

No. 1 standard pig iron	20 per cent.
Scrap	80 per cent.

Central Mexicano.

Pig iron	50 per cent.
Car wheels	25 per cent.
Machinery scrap	25 per cent.

To give a casting with 1.25 to 1.75 per cent of carbon.

The following is a list of those using a greater or less percentage of steel in their cylinder mixture:

New York Central & Hudson River.

New iron	70 per cent.
Selected scrap	25 per cent.
Boiler-plate steel clippings	5 per cent.

Southern Railway.

Embreville iron	40 per cent.
Selected car wheel	60 per cent.
Steel, about	15 per cent.

Wabash Railroad.

Close-grained gray iron with 15 per cent of steel turnings.

Chicago & North-Western R'y

Prefers a mixture of coke iron, scrap and about 20 per cent of steel cuttings, the resultant mixture having an analysis practically as follows:

Silicon	1.50 per cent.
Manganese	.35 per cent.
Phosphorus	.65 per cent.
Sulphur	.07 per cent.
Combined carbon	.60 per cent.
Graphite	2.45 per cent.

Northern Pacific Railway.

No. 1 Lake Superior pig	50 per cent.
Car wheel center scrap	25 per cent.
Selected scrap	25 per cent.

Boston & Maine Railroad.

As nearly all of our cylinders are made by locomotive builders, we have obtained specimen analyses of cylinder mixtures from three builders, as follows:

One engine built in 1895, rebored 1899, at which time it was only 3-32 inch larger than original diameter after boring; mixture as follows:

Champion No. 2	30 per cent.
Salisbury No. 4	25 per cent.
Cylinder scrap	35 per cent.
Car wheels (mileage 210,000)	10 per cent.

Mixture in several engines built in 1899:

Elk Rapids	15 per cent.
Salisbury No. 4	25 per cent.
Cylinder scrap	35 per cent.
Niagara	15 per cent.
Car wheels	10 per cent.

Although these engines are in service but a short time they are in good condition and wearing satisfactorily. This builder states that while the different brands used are not always the same, yet they endeavor to keep the mixture constant from a mechanical standpoint by analyzing each car of pig iron and proportioning the mixture so that the final chemical analysis will run as uniform as practical.

Another engine had the following composition:

Salisbury No. 3	32 per cent.
Salisbury No. 4	55 per cent.
Cylinder scrap	13 per cent.

The history of this engine shows that cracks soon developed and subsequent breakages, at which time the iron seemed to present a coarse fracture and was considered to be of insufficient strength. Whether this is a direct result of composition material is not known.

In 1893 we received six engines from another builder who has no definite analysis for these particular engines, but who submits the following as analysis of cylinder iron cast at about that time, but which fairly represents the metal used in all their cylinders for that period.

CASE NO. 1.

Test strips 1 inch square tested transversely, supports 12-inch centers.

Test piece No. 1 broke at 2,800 pounds.

Test piece No. 2 broke at 3,000 pounds.

MIXTURE.

No. 2 Crozer	1,000 pounds.
No. 2 Crane	1,000 pounds.
Chilled wheels	1,500 pounds.
No. 1 cylinder scrap	1,000 pounds.

These six engines, having 18-inch cylinders, have been in continuous service since 1893, and the following statement will indicate work done on cylinders during that time:

ENGINE.	CYLINDERS BORED.	DIAMETER.	DATE LAST GENERAL REPAIRS.
First	June, 1895.	$18\frac{1}{16}$.	March, 1896.
Second	June, 1894.	R: $18\frac{1}{4}$. L. 18.	June, 1897.
Third	June, 1895.	R. $18\frac{1}{4}$. L. $18\frac{5}{16}$.	November, 1897.
Fourth	March, 1894.		
"	January, 1899.	R. $18\frac{1}{4}$. L. $18\frac{9}{16}$.	January, 1899.
Fifth	December, 1895.		
"	June, 1897.	R. $18\frac{7}{16}$. L. $18\frac{1}{8}$.	December, 1898.
Sixth	April, 1897.	R. $18\frac{1}{2}$. L. $18\frac{3}{16}$.	June, 1899.

The wear of above cylinders has not been excessively rapid and has been as uniform as is reasonably expected under varying conditions of service.

Case No. 2.

No. 1 cylinder scrap	1,700 pounds.
Chilled wheels	1,300 pounds.
No. 2 Pioneer	750 pounds.
No. 2x Ivanho	750 pounds.

Test piece No. 1 broke at 3,000 pounds.
Test piece No. 2 broke at 2,850 pounds.

Case No. 3.

No. 2 Allegheny	600 pounds.
No. 2 Warton	600 pounds.
No. 3 Poughkeepsie	600 pounds.
No. 1 cylinder scrap	1,900 pounds.
Chilled wheels	800 pounds.

Test piece No. 1 broke at 2,925 pounds.
Test piece No. 2 broke at 2,950 pounds.

The following is cylinder iron analysis taken during the period represented by Case No. 3:

Carbon	3.382
Silicon	1.692
Phosphorus	.523
Manganese	.361
Sulphur	.085

Another builder reports the following mixture for recent cylinders cast, of which we have no record for wear, but mixture represents average cast by this builder:

No. 2 Salisbury charcoal iron	40 per cent.
No. 2 Lake Superior charcoal iron	38 per cent.
No. 3 Lake Superior charcoal iron	17 per cent.
Cylinder pig or scrap	5 per cent.

In making cylinders, to insure freedom from blow-holes, this builder runs about 400 pounds entirely through the mold and into a pig bed prepared for its reception. This iron is classified under the head of cylinder pig, is very hard and close grained, and is used again as cylinder scrap.

ata too mited to commend linder metal ixture.

From the foregoing it will be seen that it is an impossibility for your committee to derive any positive deduction or make any special recommendations.

Such roads that use specific mixtures as detailed can only be used as an illustration of the best practice in different parts of the country where the different special irons are in convenient freighting distance, and a universal mixture would be an absurdity. The nearest approach to universality would be a mixture of irons that would give a certain chemical analysis which practice had determined would give the best results. The data at hand, however, is too limited for the committee to go any further.

In this connection it seems to be a general complaint that some of our locomotive builders make their cylinders entirely too soft, presumably for the purpose of facilitating and cheapening the cost of machining, and also assisting in preventing a loss of cylinder castings due to shrinkage causing cracking.

ylinder ddles parate from linders.

Question 2. Do you or do you not get any advantage in casting cylinder saddles separate from the cylinders?

Among the replies to this question we received two favoring the cylinder and saddle as separate castings, and they simply made the assertion without giving any reasons. One road replies that it has a great many saddles with separate cylinders, which, owing to inadequate bolting to frames and boiler are frequent sources of trouble, but it believes with proper design of separate saddle and cylinders, distinct advantages are obtained, especially in ease and economy of renewal in case of breakage or cracks.

Three roads have used them more or less extensively, but considering them a positive disadvantage, have abandoned their use. The chief difficulty seems to have been that they were unable to hold them on the frames satisfactorily.

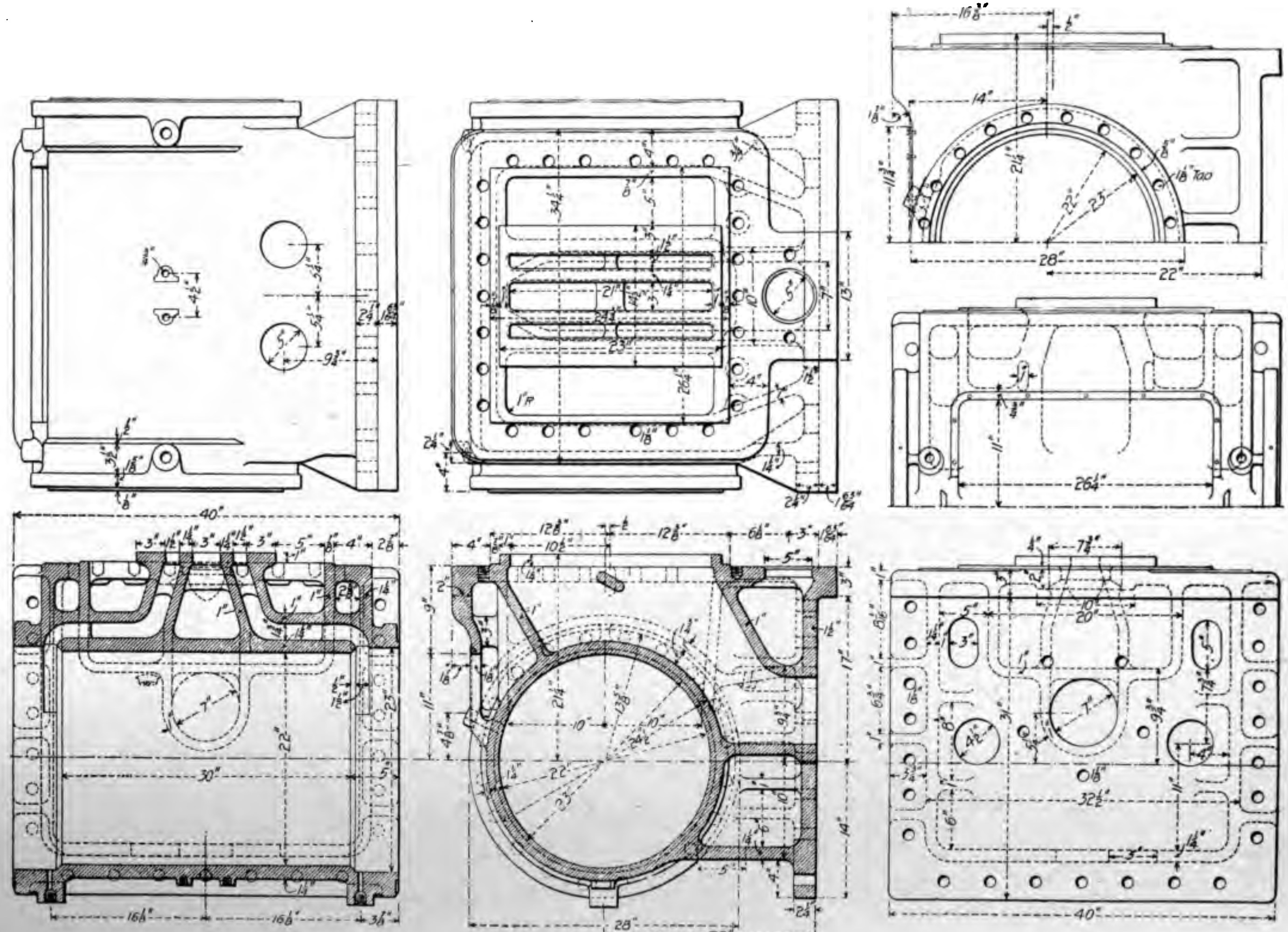
The other replies were nearly all positively against the method. One member replies that his memory still teems with the many disadvantages of this method as practiced years ago. Others do not consider it necessary to cast them separate in order to prevent cylinder saddles from cracking.

One road replies that it casts cylinder and half saddle together and prefers this construction.

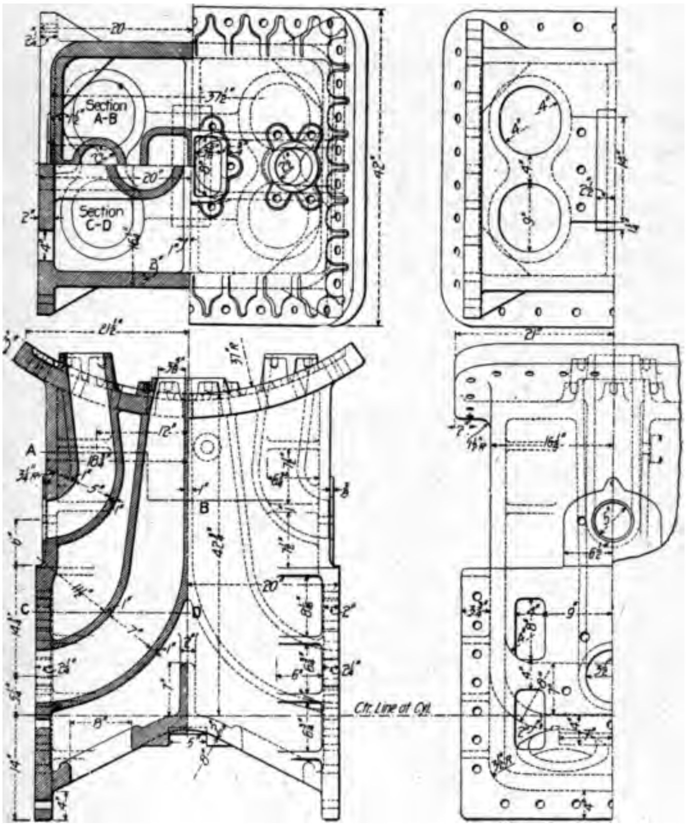
One member replies that in locomotive construction and mechanics generally that few parts is better practice than many parts. While aware that on account of the higher pressure and inadequate strength in the cylinder construction, there has been an increase in cylinder breakages, and some roads are considering the separation of cylinder from saddle. We believe that eventually they will find that the shearing of bolts that secure the cylinder to saddle and other failures incident to three pieces instead of two and to high pressures, a three-piece construction will prove to be more objectionable than a two-piece one. It would seem that the proper course to pursue when the two-piece construction is found to be weak would be to strengthen the parts that are weak, and not condemn the design as bad.

Opinion of committee as to casting cylinders and cylinder saddles separate.

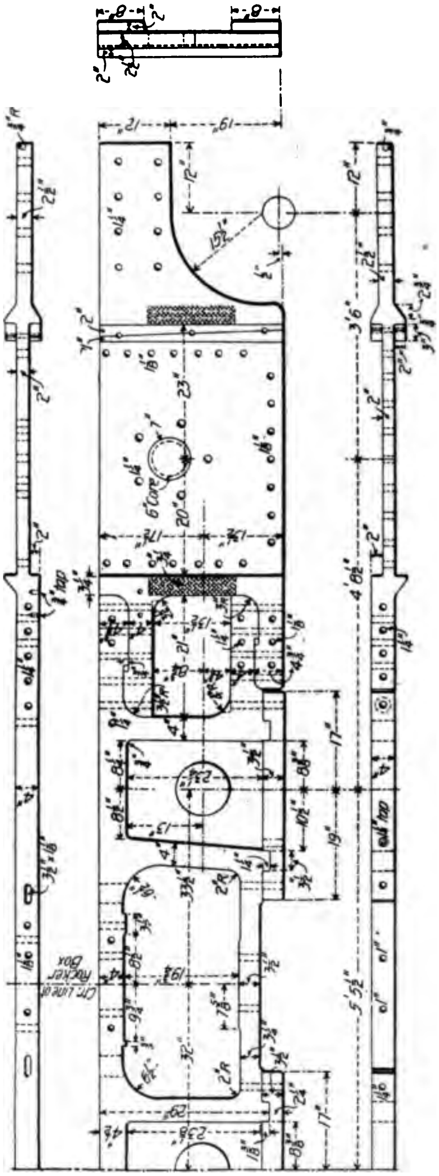
The deduction of the committee from the replies to this question would be that cylinders and saddles in one piece can be so designed, molded and handled in the foundry as to give perfect satisfaction and still be so secured to the frames as to be immovable, resulting in economy, not only as to first cost, but in cost of maintenance, although one road has been for the last two years using the three-piece cylinders and saddles, and from observations made at different times it seems they are having great success not only in keeping the cylinders secured, but they have been able to reduce to a minimum the time in which to apply a new cylinder. The method pursued by this road allows a different metal to be used in the cylinders than that in the saddle; plainly speaking, a hard metal can be used in the cylinders and a softer metal in the saddles. This arrangement seems to have advantages over the two-piece cylinder and saddle. The method of fastening is shown on following pages:



CYLINDER AND CYLINDER HEADS.


Section A-B
Section C-D
20
37½"
42"
20"
21½"
21"
12"
A
B
C
D
42⅞"
16½"
9"
Ctr. Line of Cyl.

SADDLE.



FRAME.

Breakage of cylinder saddles cast in pairs.

Question 3. Do you experience any trouble by cylinder saddles breaking when cast in pairs?

Only two members reply that they have been annoyed to the extent of changing method of construction. All others reply either that they had no trouble or that what trouble may have arisen was either due to faulty design, improper distribution of metal, shifted cores, or exposure to greatly varying temperatures when first cast. The remedy in each case, effectually applied, was better design and more mechanical care in the molding and casting.

Solid piston heads.

Question 4. Do you prefer solid piston heads? If so, is there any advantage in using same?

With the exception of five roads, all others replying are decidedly in favor of the solid piston head. Reasons given, cheaper in first cost, cheaper in maintenance and less liability to breakages, due to dispensing with center ring, follower plate and follower bolts; also have the advantages of lightness, simplicity and cheapness. While cast iron is strong enough for eighteen-inch cylinder engines and under, the majority recommend steel piston spiders for larger cylinders and heavier pressures.

The five roads not in favor of solid pistons give as their reasons for not desiring or abandoning their use:

1st. The impossibility of adjusting them to the center of the cylinder, which is hard on piston packing and guides.

2d. A much greater expense is entailed in the roundhouse when it is desired to examine the packing or renew the rings.

3d. The question of the piston head becoming too small for the cylinder cuts a greater figure with the solid head than when the spider and bull-ring type is used, as the occasional renewal of a bull ring obviates the necessity of an entire new piston head.

Deductions c committee a to use of soli piston heads

It is the opinion of the committee, however, that extraneous circumstances would have a tendency to control the use of solid pistons. For instance, a road where considerable drifting is done might have extraordinary cylinder wear with solid piston without ready means of regulating unless continuous piston rod should be used, in which case but little difficulty should be experienced and a much more safe and economical solid piston used. Again, other roads where very little drifting is done and steam used in the cylinder constantly, very little trouble should be experienced with solid pistons, especially where high pressures are used.

The committee is also of the opinion that those roads using twenty-inch and over cylinders will of necessity be compelled to use solid pistons, and of steel, in order to secure the requisite strength and keep within the desirable weight limit of piston. It is also questionable whether it will cost any more, with modern machinery, to renew an entire solid piston head than it would to renew bull rings with consequent facing of spider, follower plates and refitting of follower bolts.

Cylinder we

Question 5. Do you experience any greater cylinder wear where solid heads are used, as compared with spider or bull-ring type?

In answer to this question, two roads reply that they experience greater cylinder and piston-rod wear with solid head.

Two roads reply that they experience less wear and very notably so when extended piston rods are used.

One road replies that when solid piston heads become worn one-fourth to three-eighths of an inch smaller than cylinder, inability to line them up centrally causes the cylinders to wear more rapidly at either end.

All other replies unite in saying that no appreciable difference in wear has been perceptible.

Diminished cylinder wear by use of solid steel piston.

The committee is inclined to believe that, leaving out of the question drifting, imperfect lubrication, etc., the question of cylinder wear depends upon piston size and weight. The heavier the piston the more rapid the wear in the cylinder and piston. No reason can be seen why, under the same circumstances, the solid and built-up pistons should not wear uniformly, and as the solid piston made of steel can be made much lighter for equal strength, its use would seem to tend toward diminished cylinder wear.

Piston head and packing ring metal mixtures.

Question 6. Please give mixture of metal in piston heads and packing rings.

The majority of the replies do not give mixture, but simply state a hard, close-grained iron for bull ring and packing rings, and ordinary good locomotive castings for piston heads.

One road specifies soft gray iron. Eight roads give specific mixtures, which vary as greatly as in case of cylinder mixtures, but as they may be of value locally to other roads in same vicinity, we specify these mixtures.

SOUTHERN RAILWAY.

Prince's No. 2 iron	50 per cent.
Selected car wheel	50 per cent.
Add steel	10 per cent.

WABASH RAILWAY.

Close-grained gray iron with 15 per cent of steel turnings.

ERIE RAILROAD.

Pig iron	50 per cent.
Good engine scrap	50 per cent.

GRAND TRUNK R'Y.

Pig iron	37½ per cent.
Ordinary cast scrap	62½ per cent.

CHICAGO, ROCK ISLAND & PACIFIC.

Foundry pig iron	66 2-3 per cent.
Scrap packing rings	33 1-3 per cent.

SOUTHERN PACIFIC.

Pig iron No. 1	20 per cent.
Pig iron No. 2	20 per cent.
Selected scrap	60 per cent.

CHICAGO, MILWAUKEE & ST. PAUL.

10 per cent Mannie iron, with 5 to 6 per cent silicon.
15 per cent Sloss No. 1 soft iron.
10 per cent South Pittsburg No. 1 soft iron.
65 per cent old cast scrap.

To one hundred pounds of this mixture is added thirty pounds of old car wheels made from following mixture:

20 per cent Salisbury iron.
5 per cent Heckla iron.
10 per cent Shelby iron.
10 per cent new scrap.
55 per cent old scrap wheels.

CHICAGO & NORTH-WESTERN.

Mixture having the same analysis as in case of cylinder castings previously given.

OREGON SHORT LINE.

No. 2 foundry coke pig iron	20 per cent.
No. 2 scrap	20 per cent.
No. 1 select scrap	60 per cent.

NORTHERN PACIFIC RAILWAY.

No. 1 Lake Superior pig	25 per cent.
American Scotch pig	50 per cent.
Selected scrap	25 per cent.

Some are made of cast steel.

It would seem to the committee that the proper method of securing correct metal for piston packing and bull rings would be by making the tests upon a chemical analysis basis, but have no data to make any recommendations. It would seem to be reasonable that, with proper lubrication, much better results would be secured by using a hard metal rather than a soft one. Many roads have increased the life of their packing rings very materially, and also noticeably saved cylinder wear, by turning a groove in center of outside of packing ring about 3-16 inch deep and covering one-third of the width of the ring, the explanation being that each ring carries its lubrication with it in this groove in the shape of moist steam, which more than offsets the diminished bearing surface liability to increase the wear.

Suggestions a to proper met for packing rings and piston heads.

Question 7. How much smaller do you allow the heads to run below the diameter of the cylinder before renewing?

In answer to this question, two roads report renewing when head is worn 3-32 inch smaller than cylinder; five when worn ⅛ inch; three when worn 3-16 inch; five when worn ¼ inch; one when worn 5-16 inch; one when worn ⅜ inch; three when worn ½ inch. Others report ⅛ inch when piston is solid, ⅜ inch when piston is built up. Others have no special

Minimum diameter of piston heads before removal.

limit, but seldom renew pistons without reboring cylinders, as their facilities for doing the work make the cost nominal.

While nothing was contained in the replies, it would seem that the depth of the packing rings would have an important bearing on the allowable wear, the presumption being that those roads having the larger limit use a deeper ring than those whose limit is considerably smaller.

ameter of
cking rings.

Question 8. How much larger in diameter do you turn the packing rings above the diameter of the cylinders?

Three roads reply that they turn packing rings 1-16 inch larger than cylinder; two roads ⅛ inch; one road 3-16 inch; two roads ¼ inch; two roads ⅜ inch; one road ½ inch; one road 3-16 inch for 11-inch cylinder to ¾ inch for 30-inch cylinder, intermediate sizes proportioned; two roads, packing rings 19-inches and under, ⅛ inch; over 19 inches, 3-16 inch larger, except for two-cylinder compounds, when ¾ inch is used; one road ⅛ inch for 15-inch cylinder and ½ inch for 24-inch cylinder, intermediate cylinders in direct proportion; one road for cylinders 18 to 21 inches diameter, ¼ inch larger; 22 to 24 inches diameter, 5-16 inch larger; 25 to 28 inches diameter, ⅜ inch larger; 29 to 31 inches diameter, ½ inch larger, and 32 to 34 inches diameter, ⅝ inch larger. One road turns packing rings for follower or spider pistons ⅛ inch larger; solid pistons 19 inches in diameter and less, ¼ inch larger; 21 and 32 inch piston rings, 5-16 inch larger. One road adds 1-64 to every inch of cylinder diameter; for instance, an 18-inch cylinder would have rings 18-64 inch larger. Another road uses 1-50 of cylinder diameter, or in other words, multiplies cylinder diameter by 1.02 to get diameter of packing rings.

As a comment, it would seem that the increased diameter of packing rings over cylinder should logically bear a certain relation to cylinder diameter, and that one or the other of the latter two methods would give more uniform results. Here again, however, we run against the quality of the iron in the rings as to elasticity and ability to retain it, consequently no rule can be deduced that would be suitable under all circumstances with this variable quantity entering in as a factor.

aring metal
oys.

Question 9. Please give the committee the best alloy for various bearing metals on your heavy and fast high-pressure passenger engines.

Of the roads replying definitely to this question, the C. B. & Q. uses phosphor-bronze main engine bearings after following specifications: Copper not less than 77 per cent nor more than 81 per cent; tin not less than 9 per cent nor more than 11 per cent; lead not less than 9 per cent nor more than 11 per cent; phosphorus not less than .7 per cent nor more than 1 per cent; ingots must have a concave or shrunken surface on the upper or open side; castings must be free from blow-holes and porosity; their fracture must show an even appearance throughout and must be entirely free from oxides or dirt; material failing these requirements will be rejected; daily samples being taken from sprues for test and analysis of each day's output.

They also say that they have had exceptionally good results with both "Magnolia" and "Motor" metals in bearings of important high-speed engines, where it seemed almost impossible to make a success with phosphor-bronze.

The Oregon Short Line uses Cicero bronze on its high-speed engines, but for other service the following compositions: Driving-box brasses: Copper, 75 per cent; scrap brass, 15 per cent; tin, 10 per cent. Rod brasses: Good engine scrap, 40 per cent; copper, 54 per cent; tin, 6 per cent.

The Canadian Pacific uses Damascus bronze composed about as follows: Copper, 77 per cent; tin, 10½ per cent; lead, 12½ per cent. Side-rod bearings: Copper, 77 per cent; tin, 11 per cent; lead, 9 per cent; zinc, 3 per cent.

The Mexican National uses phosphor-bronze for all bearings and lines them with Magnolia metal.

The Southern Railway uses Ajax metal, but has had excellent results from the following: Copper, 100 pounds; tin, 14 pounds; zinc, 2 pounds; ferro manganese, 2 pounds.

The Chicago & North-Western uses Ajax and phosphor-bronze metals and considers them the best for heavy fast passenger engines.

The Chicago & Great Western uses Ajax metal.

The Chicago, Milwaukee & St. Paul uses the following: Lake copper, 6 parts; Australian tin, 1 part, and in connection with all bearing metals uses genuine babbitt whenever possible to do so.

The Erie Railroad uses the following: Tin, 11.77 parts; lead, 11.78 parts; copper, 76.45 parts.

The Wabash Railroad uses for all engine bearing brasses: Copper, 8 parts; tin, 1 part; lead, 1 part.

The Duluth, South Shore & Atlantic uses Lake copper, 6 pounds; tin, 1 pound.

The Grand Trunk uses: Copper, 11.97 parts; tin, 1.71 parts; zinc, .85 parts; scrap, 85.47 parts.

The Chicago, Rock Island & Pacific uses in driving-box brasses and rod bushings: Copper, 78 parts; tin, 16 parts; lead, 6 parts. Main rod brasses: Copper, 3 parts; Ajax metal, 1 part.

The Southern Pacific uses: Copper, 6 parts; tin, 1 part.

Northern Pacific Railway: Ajax metal, 7 parts copper, 1 part tin and 1 part lead.

The Boston & Maine Railroad uses for driving-box liners and rod bearings (medium engines) 8 parts copper, 1 part tin; for heavy engines, 7½ parts copper, 1 part tin. For engine and tender truck bearings a brass with raised babbitt bearing is used, bronze alloy sufficiently strong to hold the babbitt being all that is required.

The question of proper bearing metal for heavy fast passenger service is an important one, but it would seem from the various replies received, each one having good success with their own mixtures, that it is a question for each road to decide, after taking into due consideration design of engine, weight on square inch of bearing surface, road bed and ballast conditions, methods of oiling and quality of lubricant used.

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Question 10. Would you recommend a soft metal to be used in connection with bearing metals? If so, in what manner would you apply it? Also give alloy of same.

In answer to this question, the Wabash, Lehigh Valley, New York Central & Hudson River and Southern Railway do not use or recommend the use of soft metal in engine bearings. All other roads recommend its use. The C. B. & Q. uses Magnolia and Motor metals. The Oregon Short Line uses the following: Tin, 88 parts; copper, 4 parts; antimony, 8 parts.

The Chicago & North-Western Railway uses: Tin, 100 parts; lead, 30 parts, antimony, 20 parts; copper, 6 parts.

The Chicago, Milwaukee & St. Paul uses genuine babbitt from the old original formula.

The Grand Trunk Railway uses: Tin, 85 parts; copper, 6 parts; antimony, 9 parts.

The Chicago, Rock Island & Pacific uses for tender and engine journals: Tin, 87.4 parts; copper, 4.2 parts; antimony, 8.4 parts. One-quarter inch thick on face of brass.

The Southern Pacific uses: Copper, 6 parts; antimony, 10 parts; tin, 84 parts.

The Erie Railroad uses for main bearings solid bronze alloy. For engine truck, babbitt in grooves each side of crown: Lead, 75 parts; antimony, 15 parts; block tin, 10 parts.

The Canadian Pacific uses Damascus bronze for driving and tender bearings without soft metal. For connecting and side-rod bearings the following: Copper, 77 parts; tin, 11 parts; lead, 9 parts; zinc, 3 parts.

The Chicago Great Western uses none in driving and rod brasses, engine truck brasses being shelled and filled with: Lead, 80 parts; antimony, 20 parts. The same comments as applied to question 9 are applicable in this case also.

The Northern Pacific Railway uses a composition of soft metal, 24 parts tin, 1 part antimony and 1 part copper.

The Boston & Maine Railroad does not approve of soft metal in driving-box bearings nor in rod bearings, except in the back end of the main rod, in which case strips ⅝-inch wide running lengthwise of the journal are provided.

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Undoubtedly one of the best metals for locomotive bearings and connecting-rod boxes is what is known as "phosphor-bronze," "S" grade:

Copper	79.70 parts.
Tin	10.00 parts.
Lead	9.50 parts.
Phosphorus	.80 parts.
	100.00 parts.

The reason the above mixture is far superior to any other is owing to the fact that copper and tin phosphorized gives it a greater affinity for lead, by which it will be understood that by the method of phosphorizing employed copper is made more fluid and in a manner cleaned, which causes it to amalgamate with the lead, and lead being a natural lubricant it has its advantages in the mixture by being held in solution, and in case of a bearing becoming neglected regarding oil for a short period, the lead in a manner fulfils the want of oil.

The most important feature regarding phosphor-bronze or, in fact, any other mixture used for locomotive bearings, is the proper handling in the foundries, as it is quite frequent that the metal will be melted and held in the furnace awaiting the call of the molder, in which case the metal is roasted or burnt, rendering it absolutely worthless as a bearing metal to withstand any friction, and at such times oil or anything else will not prevent it becoming heated. It has often been the writer's experience to find two bearings made of the same lot of metal, but not cast at the same time, to find one run perfectly cool and the other to persist in heating in defiance of all that could be done to prevent it.

It is generally understood that phosphor-bronze wears from 40 to 50 per cent slower than brass, although a great many roads have their own special mixtures for engine bearings, at the same time getting good results as regards the running cool parts are concerned, but the point is to obtain the metal that will give the best results together with the longest life.

It is a well-known fact, on account of depression of business the last few years, that the contract price of bearing metal has been reduced until brassmakers have had to resort to substitutes and a great amount of scrap to come out even. Therefore, it is recommended by this committee that a fair price be paid or allowed for bearing metal, then demanding first-class material. For illustration, bearing metal at 10 cents per pound giving trouble heating does cost a company more money than bearing metal at 16 cents giving no trouble, if quality is demanded when 16 cents is paid for it. It seems that bearing metal should be based on mileage, giving cost per 1,000 miles, and not by cost per pound alone. Some roads keep their figures as per paper attached, which shows conclusively if bearing metals are giving good results and that lubrication is perfect.

Recommend tions of committee a to purchase bearing meta

LUBRICATION OF PASSENGER AND FREIGHT CARS.

MILEAGE.

	1891	1892	1893	1894	1895	1896	1897	PER CENT.	
								Inc.	Dec.
July	6,551,174	7,188,632	9,502,670	10,627,513	11,386,530	10,544,576	14,163 067	34	....
August	7,177,999	7,645,730	10,627,222	10,139,123	12,202,284	12,097,294	16.566,189	37	....
September	9,359,329	11,087,039	12,984,194	13,011,017	14,207,268	18,565,379	17,042,237	....	8
October	12,016,140	13,453,525	13,817,848	16,369,092	18,433,882	20,638,567	18.917,153	....	8
November	11,679,022	12,187,292	11,399,854	13.324,607	14,404.400	17,243,873	11,475,386	....	33
December	8,999,922	11,153,547	10,978,680	8,759,004	9,871,258	14,228,973	11,324,505	....	20
January	5,998,570	7,278 455	6,298,028	6,556,677	6,523,230	9,865.014	7,394,562	...	25
February	4,282,410	8,330,552	5,041,045	5,911,162	8,183,261	9 596,565	7,238,344	....	25
March	5,730,212	10,343,989	8,038,193	7,200,113	9,996.769	11,934,280	9,316,486	....	22
April	6,580,975	9,509,151	7,220,174	4,322,617	9,008,710	11,846,602	10,716,366	....	10
May	6,302,423	7,147,445	8,308,515	8,074 824	10,159,883	13,495,290	13,182,181	....	2
June	6,100,585	9.852.520	10,275.709	6,629,183	11,558,108	14,508,984	12,269,589	....	15
TOTAL	90,779,761	116,077,846	114,492,132	110,924,932	135,935,583	164,565,397	149,606,065	....	9

COST PER 1,000 MILES.

	1891	1892	1893	1894	1895	1896	1897	PER CENT.	
								Inc.	Dec.
Oil	21.29	20.07	20.17	19.56	13.94	10.90	11.90	9	....
Waste	3.86	4.01	3.92	3.76	2.40	2.42	2.68	11	....
Bearing	11.19	7.88	7.97	6.53	4.93	7.52	6.00	....	20
TOTAL	36 34	31.96	32.06	29.85	21.27	20.84	20.58	....	1

MILES RUN TO

	1891	1892	1893	1894	1895	1896	1897	PER CENT.	
								Inc.	Dec.
1 gal. Oil	986	1,042	1,091	1,124	1,467	1,881	1,723	....	8
1 lb. Waste.	2,329	2,242	2,103	2,194	2,753	2,789	2,625	....	6
1 lb. Bearing	790	861	1,614	1,686	2,082	1,618	2,005	24	....

COST PER 1,000 MILES — PASSENGER AND FREIGHT SEPARÂTE.

	1891		1892		1893		1894		1895		1896		1897	
	Oil.	Waste.	Oil.	Waste	Oil.	Waste.	Oil.	Waste	Oil.	Waste.	Oil.	Waste	Oil.	Waste.
Passenger	22.44	5.12	27.47	6.23	29.57	6.31	34.53	6.66	23.44	4.36	22.24	4.87	20 78	4.70
Freight	21.12	3.68	19.23	3.76	18.90	3.51	17.26	3.31	12.59	2.11	9.52	2.12	10.73	2.42

In conclusion, the committee would state that no matter what the mixture may be, foundry practice assumes almost as important a part as the mixture, to prevent hot bearings, and should be given careful consideration.

Lubrication o cylinders, valves and machinery; difficulties encountered.

Question 11. Do you experience any difficulty in lubricating cylinders and valves and machinery on your high-pressure heavy and fast passenger engines? Please give the committee the benefit of your experience on this subject.

To this question, the majority of the roads replying say that with improved lubricators, proper piping and the use of a good lubricant and high grade of oil, they are experiencing very little difficulty.

The Canadian Pacific says its chief difficulty is in the case of piston valves, but it is not enough to look upon it as chronic.

The Chicago & North-Western replies that its chief difficulty is in lubricating bearings with underhung spring rigging where the boxes and cellars are difficult of access, both for inspection and oiling.

The Southen Railway reports that it has difficulty with 200 pounds pressure, and has not found a device that will give regular feed that can be depended upon.

The Wabash Railway says that it has more or less trouble and does not consider it possible to perfectly lubricate these parts without some form of force feed lubricator. No trouble with machinery when properly attended to.

The Chicago, Milwaukee & St. Paul Railway comments as follows: We experienced difficulty with lubricating cylinders and valves, not only in high-pressure engines, but in all engines using a lubricator that is not provided with some device for giving a constant feed of the oil to the cylinders. Extensive tests in this direction showed us that any of the ordinary cylinder lubricators not provided with a special device would not feed oil to the cylinders and valves when the cylinder pressure is greater than sixty per cent of the boiler pressure, although there are now in the market devices that will overcome this trouble and will give a constant feed with ordinary lubricator.

The Chicago, Burlington & Quincy reports that lubricator companies have appreciated former difficulties and that as now made they seem to work satisfactorily. The principal difficulties we have had with lubricating cylinders seem to be due to two sources: First, from front end gases, which, if drawn down from exhaust nozzle when drifting, dries up the lubrication in the cylinders and steam chest; second, from carrying over water or wet steam to the cylinders and steam chest, thus washing away the mineral oil in the lubricant. We have been a good deal troubled with bad water recently, and the use of soda ash to prevent the formation of hard scale on boilers has of course increased the tendency to foaming and carrying over water with the steam.

The Northern Pacific Railway reports that it has had no difficulty except in lubricating valves and more difficulty with high-pressure slide valves of the "D" type upon two-cylinder compounds (valves of the same kind upon simple engines) carrying 200 pounds boiler pressure than upon others. The trouble has been greater in certain districts where water is very bad and causes foaming. The use of lubricators of latest type designed expressly for use on high-pressure engines has reduced the trouble to a minimum.

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ainable.

The Boston & Maine Railroad reports difficulty on engines carrying 200 pounds pressure, in which it is difficult to force oil into chests. With large steam connection directly from boiler (instead of combination stand) to lubricator and use of recent improvements in lubricator attachments, defective feeding has been partially remedied.

Commenting on the replies to this question, it is the opinion of the members of this committee that with the modern lubricator, properly applied and operated, very little difficulty should be encountered in securing proper lubrication to valves and pistons, providing a proper lubricant and sufficient of it is used.

cation of
holes,
oves and
kets in
ving boxes.

Question 12. What do you consider the best method of locating oil holes, oil grooves and oil pockets in driving boxes?

Answering this question, the majority of the roads favor oiling journal driving bearings by carrying oil to crown cavity, either centrally from one oil pocket on top of box, or from two cavities on top of box by means of holes drilled at an angle to reach crown cavity.

The Chicago, Burlington & Quincy Railroad replies that it has tried and is still trying oil holes and oil grooves on the side, and has tried to do away with the center oil hole in the top, but thus far with only moderate success. The trouble seems to be that the waste from the driving box is grated up and soon plugs up the grooves and the oil holes on the rear side, and if the box runs at all warm the metal tends to "wipe" over the groove on the front side. On the whole, it seems that the side oiling is of very doubtful advantage.

The Chicago, Milwaukee & St. Paul Railway replies that it considers four recesses for oil on top of driving box as the best practice. The two outside ones to furnish lubrication for the wedge and shoe, with an oil hole about one-third the depth of the recess from the top, same to be filled with waste and oil from the top in usual way, the waste to deliver the oil to the wedge through this oil hole; the two center recesses to be the oil reservoir for oiling the bearing. This is also to be filled with waste and the oil hole from the top of the box to the bearing to enter two distributing reservoirs located about 1½ inches either side of the top center of the brass. We have also had very favorable results from an oil hole drilled vertically through the flange of the driving box, entering the cellar at a point just below the edge of the brass and communicating with a perforated pipe placed in the top edge of the driving-box cellar; by oiling through this hole, the oil is conveyed directly to the cellar and is distributed through its entire length by this perforated pipe. In actual practice, it is noticed that the waste gathers around this pipe, pressing close to the journal, but never packs or becomes dry or hard, but lubricates constantly, keeping it soft and free.

The Erie Railroad favors large oil cavity on top of box, three oil grooves in boxes, two ½-inch holes to middle groove and ¼-inch hole each side to grooves. Separate oil cavity on each side for wedges; two oil holes from each ¼-inch in diameter.

The New York Central & Hudson River Railroad favors lubricating at the side just above the center of the axle. Its experience in oiling driving boxes that way has been somewhat limited, although on a number of engines being turned out with holes drilled toward the center of the boxes the result has been very satisfactory.

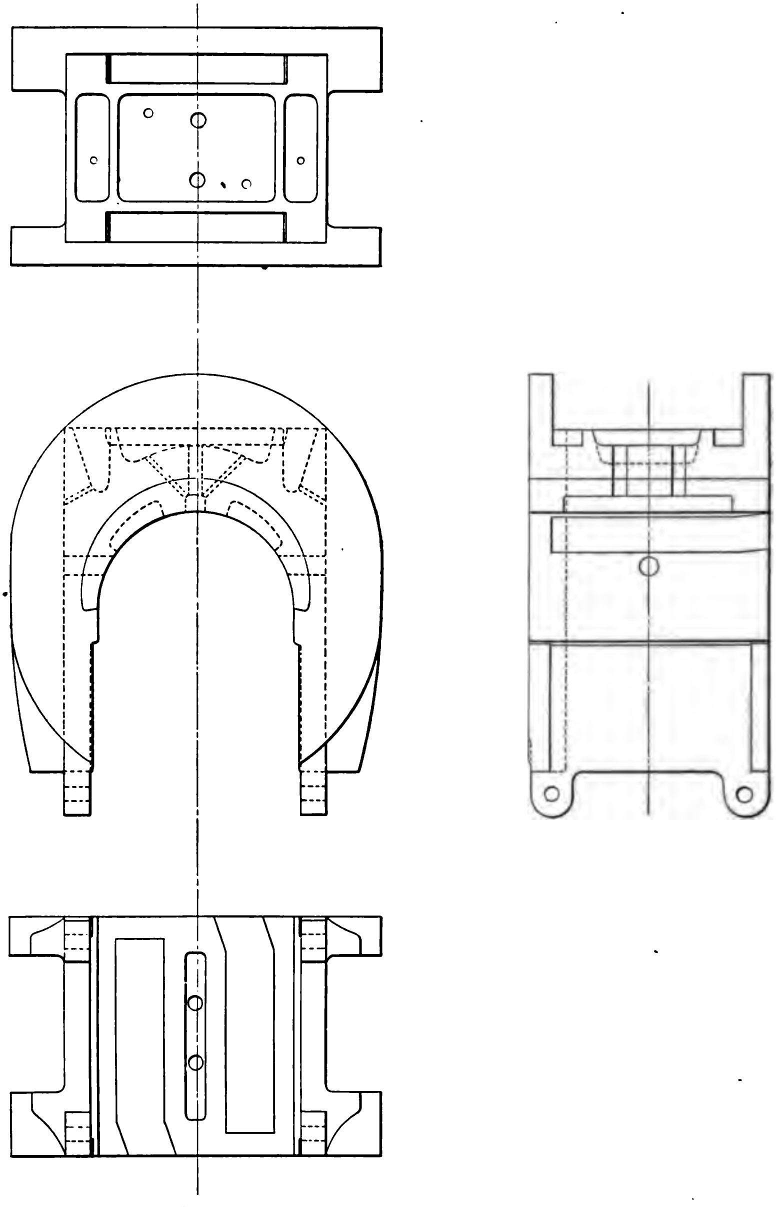
The Southern Railway replies that it has good results from oilways cast in brass on outside next to box. These grooves are about ⅜-inch wide and run across the brass to within ½-inch of edges; ¼-inch holes located near the end of groove and drilled through brass and box; grooves are placed, one on top and one on each side of top; one at an angle of about thirty degrees from center of axle and perpendicular line. Also have good results from oilway cast in crown or outside of bearing, with oil holes drilled through brass and box at an angle of thirty degrees from perpendicular on each side of the oilway in crown.

The Southern Railway of Peru says that it locates oil holes on the sides of journal boxes and has done away with oil grooves and pockets, depending upon the cellars for lubricating the journals.

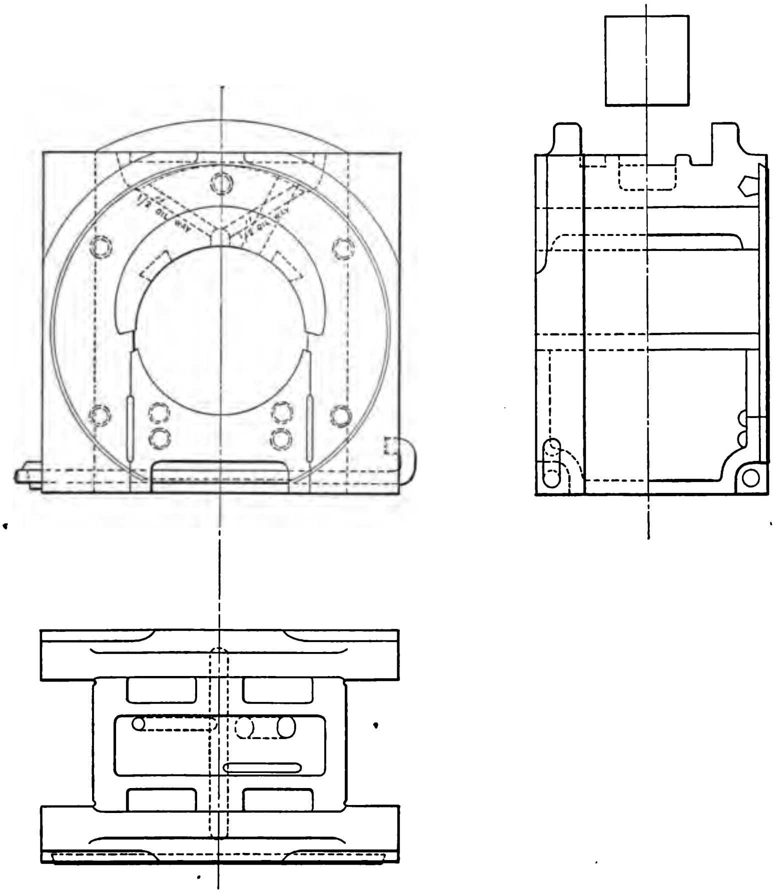
The Boston & Maine Railroad advises that driving boxes are best oiled by two oil grooves running lengthwise of bearing located on each side well away from the crown, oil holes leading to these grooves from large pockets in top of box.

The following roads have furnished blue prints of their methods of lubricating driving boxes. A glimpse at the cuts which are reproduced will show better than verbal explanation their methods and differences:

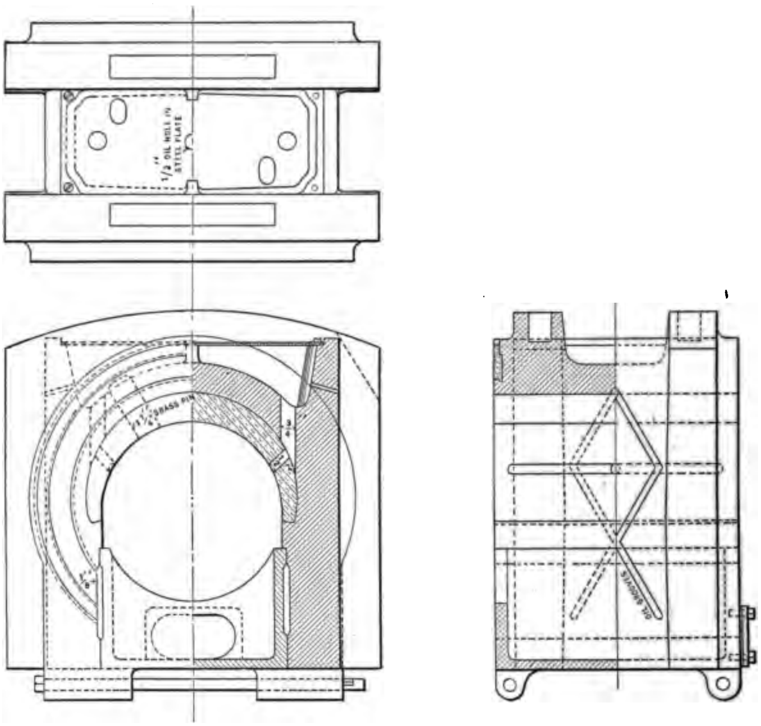
Chicago & North-Western, Grand Trunk, Canadian Pacific, Oregon Short Line, Chicago Great Western, Mexican Central and Northern Pacific Railways.



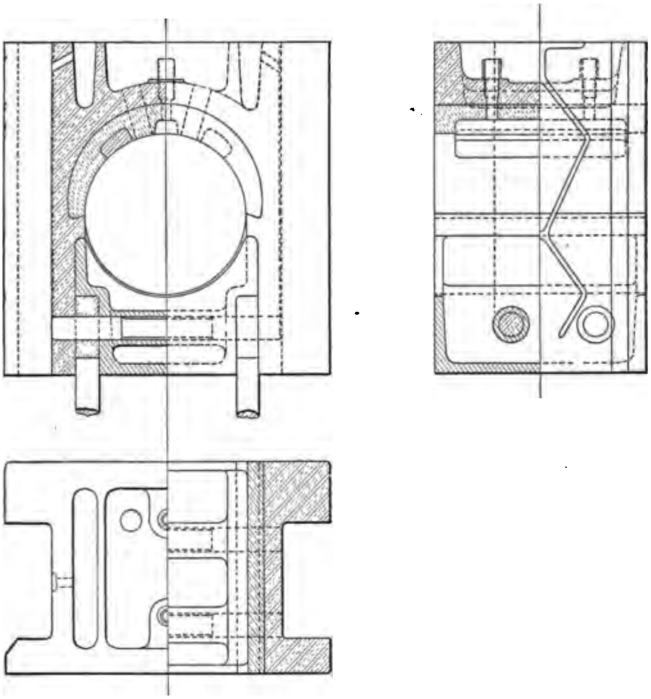
Mexican Central Railway Company.



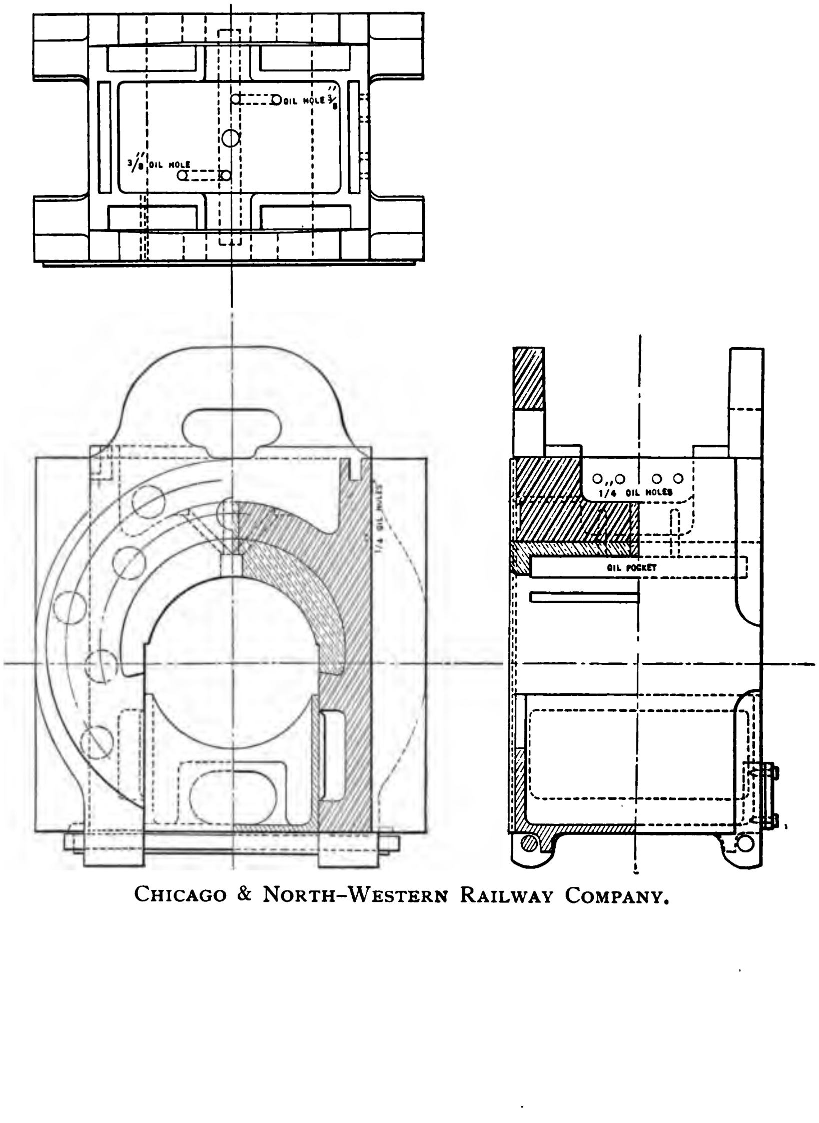
Oregon Short Line.



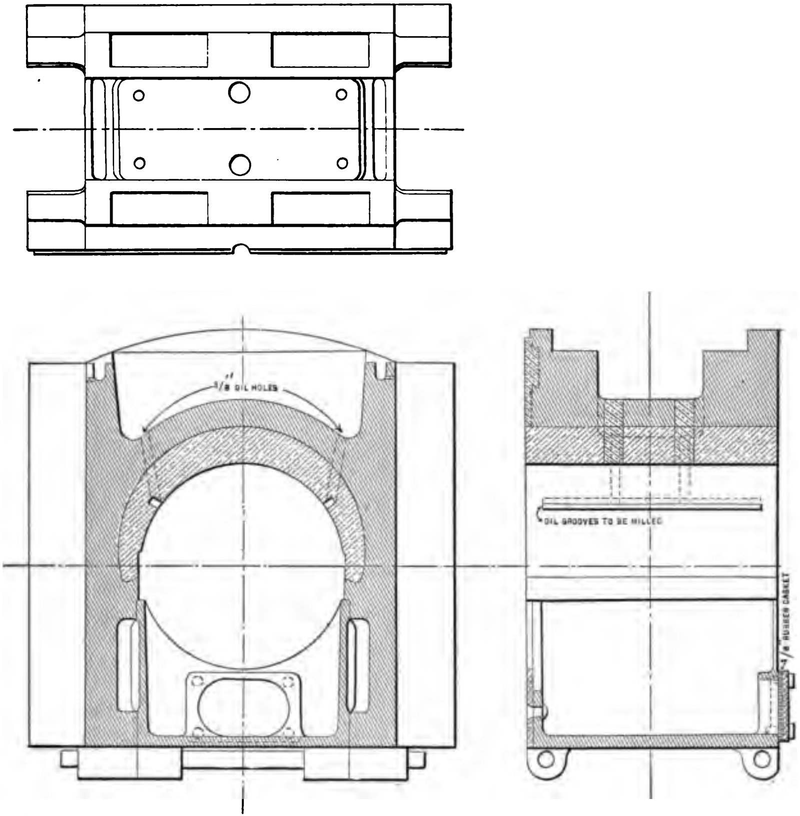
CHICAGO GREAT WESTERN RAILWAY.



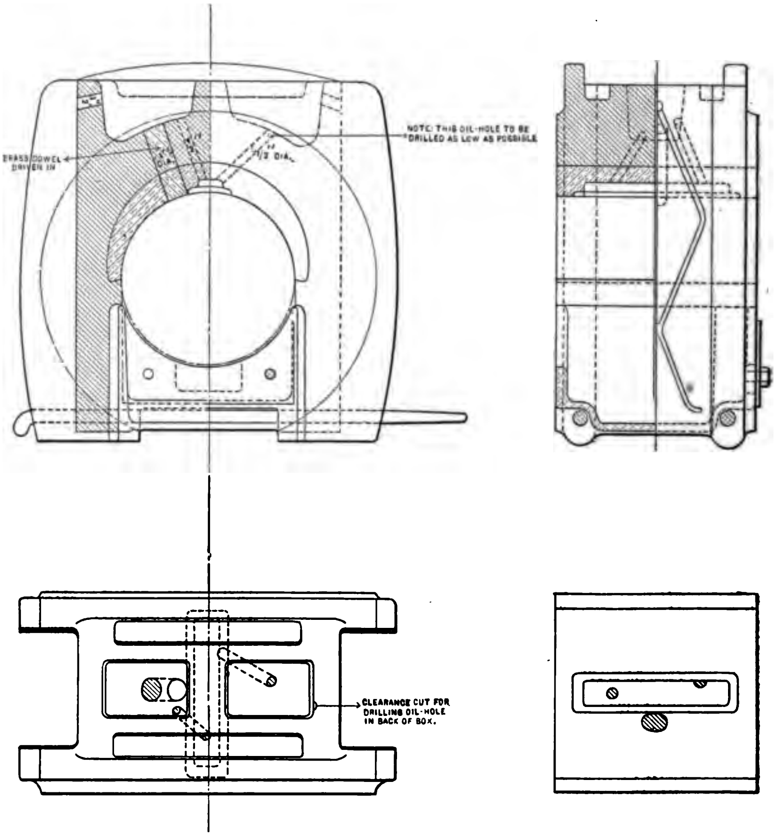
GRAND TRUNK RAILWAY-SYSTEM.



Chicago & North-Western Railway Company.



NORTHERN PACIFIC RAILWAY COMPANY.


NOTE: THIS OIL-HOLE TO BE DRILLED AS LOW AS POSSIBLE
BRASS DOWEL DRIVEN IN
1/2" DIA.
CLEARANCE CUT FOR DRILLING OIL-HOLE IN BACK OF BOX.

Canadian Pacific Railway Company.

We also append herewith a communication from Mr. G. M. Basford, an associate member of the Association, that is very worthy of reproduction, bearing closely as it does upon the subject matter in hand:

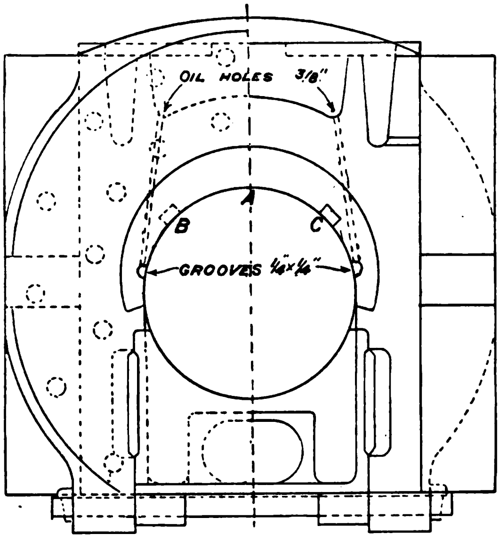
"On page 91 of the *American Engineer and Railroad Journal,* for March, 1898, you will find an article upon the subject of the advantages of introducing oil at the sides rather than at the top of the bearing of the driving box. This article gives the reason why it is advantageous to admit the oil elsewhere than at the top. The reason is that in the case of a rapidly revolving journal there is actually a pressure of the oil at the top of the bearing. Experiments made some time ago in England developed the fact that a bearing loaded at its top showed a pressure of oil when measured by a gauge attached to the oil hole. Carrying the experiment further, it was found that when the hole was located beyond the center of the shaft, the load being applied as before, on the top, the air in the hole adhered to the shaft and was carried around with it, causing a vacuum in the oil hole, which could be measured by a gauge. Under the most favorable conditions for the vacuum it amounted to, I believe, about thirty inches. From the experiments the following conclusion was drawn:

"That bearing surfaces that are properly lubricated are separated by a film of oil at a pressure per square inch equal to the load that is upon them. The realization of this fact suggested the following rule, which may be applied to nearly all classes of bearings:

"Introduce the oil at the points of least pressure, and do not provide a means for escape for it at the points of greatest pressure.

"I would like to send you a copy of the paper containing this article, but can not do so, as it is out of print. Should you be sufficiently interested to request it I can have a typewritten copy of it made for you.

"I am sending you a diagram 'A', which shows the construction of a driving box which is arranged in accordance with this suggestion.



"The experiment started with the construction of a polar diagram, by which it was shown that when the engine is running at speed there is practically no difference in the radial pressure at the crown of the box and at a point forty-five degrees away from it, and that the pressure gradually diminishes down to the horizontal center line of the axle. This pointed to the desirability of the removal of the oil cavities in the crown, shown at 'A' in the diagram, and also at 'B' and 'C' (the forty-five degree points), and the substitution of two narrow and shallow horizontal grooves cut across the box slightly above the horizontal center line at each side. These grooves were milled into the shell and ⅜-inch holes were drilled down into the grooves from the oil cavity in the top of the box, and the oil was fed through these to the bearing. I understand that while this location of the grooves when substituted for the admission of oil at points 'A', 'B' and 'C' did not absolutely and completely stop all troubles with hot driving boxes upon the road where this experiment was tried, it did improve matters greatly and saved a lot of trouble which had previously been experienced.

"It is my opinion that an arrangement of this kind, in which provision could be made for keeping the grooves clean—that is, free from dirt—would be a great improvement upon prevailing methods."

In addition to this letter the committee has observed that some roads are slotting out driving shells or boxes 1¼ inches above center of axle (when diameter of axle is 9 inches, others in proportion), clearing axle 1-16 inch, and the side grooves are placed 1 5-16 above top of clearance, or the oil groove is placed 2 9-16 above center of axle. Very satisfactory results are obtained by this arrangement.

W. C. DALLAS, Chairman.
J. B. BARNES,
G. F. WILSON,
Committee.

ST. PAUL, MINN., May 10, 1900.

THE PRESIDENT: Gentlemen, what is your pleasure with the report?

A MEMBER: I move that it be accepted. Carried.

THE PRESIDENT: The paper is now open for discussion. I wish to say, gentlemen, that there are a great many important things in this paper which will be of great interest to the Association, particularly in regard to the mixture of various bearing metals, and we have with us this morning Mr. G. H. Clamer, the chemist of the Ajax Metal Company, and if there are no objections we would like to hear from him as regards the amalgamation of certain metals and the effect of lead in copper and tin.

MR. GUILLIAM H. CLAMER (Ajax Metal Company): Mr. President, in looking over this report on journal bearings, it seems to me that inasmuch as so much uncertainty exists relative to what the composition of the bearing metal should be that it would be well if more attention were paid to this subject. I notice that the different roads, almost every one, have a different composition, and I venture to say that, in the case of the majority of the railroads in this country, they do not know what the composition of their bearing metal really is. I have paid a good deal of attention to this subject during the past years and have carried out some experiments principally with the introduction of lead in these bearings. I think it would be well in the consideration of this subject if we would have before us, first, the requirements which should be met by a good bearing alloy. These requirements — that is, the general requirements — I think may be summed up under four heads: First, that the metal should show the least liability of heating under all circumstances. Second that it should have sufficient strength and a sufficiently high melting point not to be squeezed out under the effects of load and friction. Third, that it should show the least possible abrasion in service; and fourth, that it should show the least possible abrasion of the journal. There are but four common metals which can constitute the basis of a journal bearing. They are copper, tin, lead and zinc. These metals may be alloyed in various proportions with each other or with other metals, so that innumerable formulæ may be compounded, but they may be summed up under three general heads: First, the white metals, or as they are sometimes called, soft metals, which include the metals having as their basis either tin, lead or zinc. The second class are the ordinary bronzes or the simple copper and tin, or copper, tin and zinc. The third are the plastic bronzes, which are copper and tin alloys containing lead, of which phosphor-bronze is a type, and this class of metals I find seems to be the one chiefly used today.

The white metals meet most satisfactorily the first requirement; that is, they possess greater anti-friction qualities than the other two classes. I do not mean to say that the coefficient of friction is less, but on account of their plasticity, they, by their constitution, are enabled to adapt themselves to any irregularities of the journal or of grit particles, and thus distribute the load evenly over the journal. They do not meet the second requirement of having strength and a sufficiently high melting point. They are first as regards the third requirement; that is, they show less abrasion in service than any of the other metals. It seems to be the common opinion among many that a hard metal is requisite to resist wear; but this I find to be an entirely mistaken idea, because lead, which is the most plastic of all metals, if it is run under a pressure insufficient to cause a permanent distortion, will resist wear more than any of the other combinations of metal. I have seen instances of a lead lining one-sixteenth of an inch in thickness which had been in service for over nine months and was not yet worn off.

The ordinary bronzes do not meet the first requirement; they are hard and unyielding by their nature and any irregularities of the journal cause the load to be localized on one or more points, thus creating friction and cutting. They of course have insufficient strength, but as far as wear is concerned, the wear is considerably more than is the case with the white metals.

The plastic bronzes which contain lead are between the two as regards wear, and the wear decreases with the increase of lead in this alloy. The valuable experiments which were made by Dr. Dudley some years ago are probably well known to many of us. The conclusion which he drew from his experiments with the copper, tin and lead compositions were that wear decreased with the increase of lead, and it also decreased with the decrease of tin, thus showing that as the plasticity of the metal is increased the wear is decreased. They approach the white metals in this respect.

The copper, tin and lead alloy by microscopic examination shows a structure similar to the honeycomb, in which the copper and tin form the cell walls, and the lead may be represented by the honey which is enclosed in these walls. Thus an alloy of this nature is given the strength of the copper and tin and the plasticity and anti-frictional qualities of the lead.

I notice in this report that mention is made of the lubricating quality of the lead. Now, this is so to a certain extent, although the babbitt metals, such as have lead for their basis, show a greater coefficient of friction than the copper, tin and lead alloys; still the lead, on account of its lubricating qualities, seems to decrease the friction in such an alloy as this.

But to sum up the question, I would say that as regards the first and third requisites, that is, as regards the anti-frictional qualities and wear, this is most perfectly met by the white metals, but they fail by having insufficient strength and a melting point which is so low that in case of accidental heating they would squeeze out. They also fail to meet the fourth requirement because they cause a rapid abrasion of the journal.

Zinc, though it has a comparatively high melting point, has the

	Friction (in lbs.).	Temperature (above temp. of room).	Actual wear (in grains). 1,000,000 revo.	Compression at yield point (lbs. per sq. in.).
Phosphor-bronze	18½	50	10.5	31,700
Plastic bronze A, 21 per cent lead	16	44	6.7	19,100
Plastic bronze B, 30 per cent lead	16	40	3.06	17,210
Plastic bronze C, 47 per cent lead	13½	34	1.65	6,690

PENNSYLVANIA RAILROAD COMPANY'S TESTS.

METAL TESTED.	COMPOSITION.					RELATIVE WEAR.	
	Copper.	Tin.	Lead.	Phosphorus.	Arsenic.		
Phosphor-bronze (standard)	79.70	10	9.60	0.80	....	1.00	
Ordinary bronze	87.50	12.50	....	....	....	1.49	
Arsenic bronze A	89.20	10.00	....	....	0.80	1.42	
" " B	82.20	10.00	7.00	....	0.80	1.15	
" " C	79.70	10.00	9.50	....	0.80	1.01	
Bronze K	77.00	10.50	12.50	....	....	0.92	
Alloy B	77.00	8.00	15.00	....	....	0.86	
Plastic bronze A	68.00	10.00	21.00	....	....	0.67	Tests made on Olsen machine.
" " B	64.00	5.00	30.00	....	....	0.29	
" " C	48.00	....	47.00	....	....	0.16	

MR. BARTLETT: I would like to ask the gentleman who has just spoken if he has had any experience with nickel in bearings; whether there is any prospect that nickel is going to improve bearing metal?

MR. CLAMER: The whole secret in holding up a high percentage of lead I might say was directly due to a small percentage of nickel in this alloy, the property of the nickel being to chill the alloy quickly, and in this rapid chilling a greater percentage of lead can be held up than otherwise could be. The proportion of lead heretofore introduced was not over fifteen to twenty per cent, but by the addition of a small percentage of nickel and the raising of the melting point of the alloy, almost any percentage of lead can be alloyed.

MR. ATKINSON: I would like to ask what flux he used to enable him to make the mixture without oxidizing.

MR. CLAMER: We use no flux whatever except a little charcoal on the top of the mixture before pouring.

Mr. Atkinson: I have always found that charcoal would not prevent slight oxidation in melting soft metal and have had to adopt a flux which was virtually a glass and impervious to air.

Mr. Delano: I want to point out one thing. A great many roads think they are using a hard metal bearing, but in all cases, however hard their bearing, they use a lead lining. That lead lining began by being a thin detached sheet of lead. Afterward it was lead that was poured in and began by being one-sixteenth of an inch thick, and it has gradually grown from that. My observation is that on roads using a hard metal bearing, a majority of the running is done on the lead lining and that the brass is taken out soon after the lead lining is worn out, the brass rebored and relined again. I mention that because I think it is very easy to deceive yourself about it, and as I do not believe that the lead lining makes a good bearing metal on account of its being too soft and forming a lap with grit and sand, I believe we should look for some suitable bearing metal for a filled brass.

Mr. Whyte: The committee seems to have been in doubt as to what recommendations to make for securing a hard metal in the cylinder, that is, a hard wearing surface inside the cylinder, and at the same time providing a soft metal in the saddle. It seems to prefer the saddle cast with the cylinder, but thinks it desirable to have the wearing surface of the cylinder harder than the saddle. It is not necessary to use the separate saddle in order to get the advantage of the hard metal in the cylinder. The cylinder may be bushed, and it is the practice of some roads to bush cylinders, even when the engines are first built. To get full advantage of this, then, the valve seat, also, should be what is called a false seat, so that it can be made of hard metal, too; with this combination, I should think that the committee might have recommended the saddle being cast with the cylinder and the cylinder bushed and a false valve seat used.

On motion of Mr. Sinclair, the discussion was closed.

The President: The next subject is the report of the Committee on Piston Valves. I understand that none of the committee are present today. I would ask the Secretary to read the conclusions of the committee, if there are any.

The Secretary read the report of the committee, as follows:

REPORT OF COMMITTEE ON PISTON VALVES.

To the President and Members of the
American Railway Master Mechanics' Association:

Your committee appointed to report on Piston Valves for Locomotives, begs to submit the following as a result of its investigation:

Two weeks after the appointment of the committee last year, a circular was prepared asking certain questions covering the use of piston valves in locomotives. This circular was sent to all the members of the Master Mechanics' Association, and while a comparatively small number of the members are using piston valves on their locomotives, yet it is found that a majority of those that have used the piston valve make replies which in nearly all cases are exceedingly favorable to the piston valve.

It is not the intention of the committee to go into all the numerous details of piston-valve constructions that have been tried, inasmuch as most of the variations are the result of individual opinions as to construction and do not affect the general result. The committee feels, however, that it can cover the important features in this report and speak with reasonable certainty. As stated previously, nearly all of those reporting as having had experience with the piston valve speak favorably of it, and this, in the judgment of your committee, is satisfactory evidence that it has merit.

The advantages of the piston valve are generally stated as follows:

For steam pressures exceeding 185 pounds the piston valve offers considerably less resistance than the slide valve, thus reducing the work the entire valve-gear must perform, and reduces the internal resistance of the locomotive, which is thought to be considerable in modern high-pressure engines.

For steam pressures higher than 185 pounds the question of valve lubrication is very much simplified and the difficulties of cut valves and seats are very much diminished.

The cost of maintaining the piston valve seems to be no greater than that of maintaining the slide valve. This statement is not based on a large number of figures, but rather on the judgment of those using the piston valve.

The area of admission and exit openings can be very materially increased with the piston valves, which, with higher power locomotives, seems to be a very important advantage, and it is well known that, in order to obtain the highest efficiency from a locomotive, it is not only necessary to get the steam into the cylinder promptly, but to get it out again.

These are, in short, the advantages of the piston valve that seem to have been demonstrated. The committee believes that, in adapting the piston valve to the simple engine, the internal admission type has possibly a slight advantage in that the loss of heat of steam going into the cylinders is somewhat less than in the case of the external admission type.

Some railroads and locomotive builders, when designing valve-gear for piston valves having internal admission, assumed that the valve gear as designed for external admission would answer for those with internal admission. Practice develops that this is a mistake, and that in order to obtain the proper steam distribution, the valve gear must be specially designed for the internal admission.

In designing the piston valve attention is called to the necessity of obtaining the benefit of all the area of admission and exhaust which the principle of the piston valve affords. The committee thinks that this has not always been taken advantage of to the full extent.

One point in piston-valve construction that has been found to have a material effect on steam distribution has been somewhat overlooked, namely, the difference in area between the forward and rear end, the area of the rear end being reduced by the area of the valve rod; the two ends are therefore out of balance, and as a result the motion of the valve in one direction is deranged as compared with the motion in the other direction, inasmuch as the lost motion in the valve-gear is taken up in an opposite direction from that which is ordinarily the case. This is based upon experiment on the part of the committee, and from the statement of an individual to the effect that a locomotive equipped with piston valves ran for quite a distance with one of the valve-stems broken, the valve making its regular movement by being pushed ahead by the end of the broken valve-stem in one direction, and pushed back again in the opposite direction by the excess pressure on the forward end of the valve.

The committee finds a great variety of packing used for piston valves. It can be said, however, with perfect certainty that plain snap packing rings will give entirely satisfactory service.

S. P. Bush, Chairman,
Wm. McIntosh,
H. Schlacks,
Committee.

Milwaukee, Wis., June 2, 1900.

Mr. Rhodes: I move that the report be received.

The motion was carried.

Mr. McNaughton: There is not much that I would care to say in this connection, Mr. President. I would like to hear from others. There is one question, however, I would like to ask Mr. Atkinson, of the Canadian Pacific. He refers to a certain difficulty in lubricating the piston valves.

Mr. Atkinson: I can only say, Mr. President, that I have not looked into it very closely. We have had difficulty and have found the wear sometimes considerable, especially where the piston valve is driven with the stem off the center, insomuch that sometimes it breaks the connecting rod.

Mr. Delano: My predecessor adopted piston valves on some simple engines and they did so well that they might be said to be standard on the Burlington Road today for all new work. I think the C. B. & Q. proper and System Lines have about sixty-five simple engines with piston valves. They all take steam on the inside although the performance of these engines has been very carefully watched. We were unable to furnish the committee with any definite data about the matter; in fact, we feel that the thing is somewhat in an experimental state. At the same time we feel absolutely confident that if it is not just exactly right we *will* make it right and *can* make it right. I am aware that piston valves were tried as much as thirty or forty years ago on locomotives and have been tried since and discarded. One of the great troubles has been with packing rings, but as we got into the thing we found that in stationary practice and in marine practice the piston valve was so absolutely satisfactory that we made up our minds it would have to be satisfactory in locomotive practice, and we would follow it up until we made it so. With this object in view we have been watching the performance of some engines and making dynamometer tests and taking indicator cards, and we think the piston valve is gradually emerging, as another committee said, from the experimental stage. In that emerging we are very confident that we will make it absolutely successful. The engineers on engines with piston valve speak very highly of the ease by which they can move the reverse levers. One of the conclusions we have come to that may be of interest to the committee is that, with a piston valve, with internal steam, if the valve is closed there is a negative pressure on a portion of the movement; that is to say, our valve friction tests show that the valve runs away from the stem. We think that that is more or less objectionable in tending to pull and push all the lost motion that there may be in the valve motion, and we have come to the conclusion that a valve with a hole through it is a better thing. There is an objection, however, to a valve with a hole through it, in that the live steam is jacketed by the exhaust steam and refrigerated to some extent. So that we have a choice between these two evils.

THE PRESIDENT: Professor Goss, cannot we hear from you on this subject?

PROFESSOR GOSS: Mr. President, there is not very much that I can say. I have had no experience with piston valves. The committee suggests that by the use of such valves the internal resistance of the locomotive may be considerably reduced. I think that the energy absorbed by valves, even though they may work very hard, never amounts to any considerable portion of the total energy developed by the locomotive. The forces transmitted by the valve spindles may be considerable, but the distance traveled by the valve when compared with that passed over by the piston is small, and it is for this reason that the energy absorbed is small. In reducing valve friction, therefore, we do not materially reduce the internal resistance of the machine.

The trouble which is introduced by the presence of excessive valve friction is to be found in a weak and distorted distribution of steam in the cylinders. The advantage to be derived from the adoption of the piston valve is in a more perfect distribution of steam, a result of low frictional resistance.

MR. BROWN: I would like to ask the members who use these valves if they experience any difficulty in the lubrication of the cylinder with the use of piston valves?

MR. HENDERSON: We have a few engines with piston valves running on the road with which I am connected, and on the Norfolk & Western, where I was previously, we had quite a number, and I would say we had no difficulty in regard to the lubrication at all; we hear no complaints. As a matter of fact, as referred to by Mr. Delano, as far as the valves are concerned, it is very much easier to handle the engine. I found recently that you could move the reverse lever, running fifty miles an hour, with one hand, very readily, without having to brace yourself.

There is one point in this report I would like to refer to. It speaks on the second page about the valve motion having to be specially designed to suit internal admission. The only thing you have to look after is this: With the ordinary Stevenson valve motion, where we have the admission at the outer edge of the valve and the reversing rocker, the angularity of the eccentric rods seems to offset the angularity of the connecting rod and equalize the cut-off. If you use a central admission valve and use the same rocker, it is necessary to give a considerable off-set to the bridge-pin on the link, possibly an inch and a half, to equalize the cut-off. But if you use the central admission and the direct motion, you see at once that you maintain the same relative position of the parts and you can use the bridge-pin in the same place. The engine which some of the gentlemen have seen down on the tracks at the station has one-quarter of an inch variation in the cut-off at full gear, and gradually diminishing to about half the stroke when the cut-off was the same front and back, and down to quarter stroke the cut-off was identical both front and back. That was arranged by having direct connection from the link block up to the rocker, which had both arms bent down. In other words, it was a direct motion, and of course we got the great advantage of that motion, and I think in that form we get about as good a cut-off as anyone could expect, obtaining, as I said, the coincidence of cut-off, front and back, from half stroke to quarter stroke. The lead is in line forward gear and increases to 7-32 lead with six inches cut-off. I think that valve gear, as far as the coincidence of the cut-off is concerned, cannot fail to be satisfactory.

MR. ATKINSON: I would like to ask Mr. Henderson if he had any difficulty in arranging the cut-off when in back gear. It is easy to get it in forward gear but somewhat difficult in back gear.

MR. HENDERSON: I do not bear in mind exactly what the cut-off was in back gear. Being a passenger engine intended to run ahead entirely, there was comparatively little attention given to the back motion.

MR. HAWKSWORTH: We have a small engine fitted with a piston valve in one of our shops that has been in service for about twenty-seven years. We have scarcely had to do anything to it all. That goes to show that a piston valve can be used a long time. We have a number of locomotives on our line with piston valves doing very nice work.

MR. W. A. BROWN: On the line I represent we have twenty-seven piston-valve engines, ten of them in service for almost three years, the balance from six months to eighteen months, and we have experienced little or no difficulty other than that which is common to the introduction of that kind. When the first lot was put into service we did experience some slight trouble due to distribution as the result of internal admission. We increased the offset of the saddle from 1⅛ to 1⅜ inches. After this was done, we succeeded in getting distribution as perfect as with the common slide valve.

In point of cylinder lubrication we have experienced no difficulty whatever. The engines could be handled with one hand, as Mr. Henderson said, running at any rate of speed from one mile to seventy miles, with perfect ease. I am satisfied from the experience we have had that it is the coming valve for locomotive service.

MR. HENDERSON: I do not want to take up all the time on this subject, but there is one point in the piston valve to which I would like to call attention, which I think has probably not received its full share of consideration, and that is the specific design of the packing ring. We know that solid valves have been used in some places, I do not know with what success, but we have had some experience that was not entirely satisfactory. I believe that the plain snap ring, the same as was ordinarily used and is used yet in pistons, is about as satisfactory a device as can be obtained, for this reason: The bushing, of course, will wear a little large at the center portion where the valve does most of its travel, and in case we imagine it is 1-32 large at that part of the travel, any piston valve that is arranged to fit solidly and tightly, if it is tight in one part it will be loose in another. Now, the spring rings are perfectly flexible and will adjust themselves to small irregularities in the diameter of the bushing, and I think that the spring ring has a great advantage just on that point, that if the valve travels the full length, and there is a small variation in the diameter due to wear, that the ring will adjust itself to it, whereas, in valves that are fitted up solidly and there is no expansion in the ring, if it is tight at one point it will be loose at the other, and it is either going to blow or catch. I think that is one point worth considering in designing piston valves.

On motion of Mr. Morris the discussion was closed.

THE PRESIDENT: The next report is on " Power Transmission by Shafting *vs.* Electricity."

The report of the committee on this subject was presented by Mr. Gibbs, and is as follows:

REPORT OF COMMITTEE ON POWER TRANSMISSION BY SHAFTING VS. ELECTRICITY.

To the President and Members of the
American Railway Master Mechanics' Association:

In absence of definite instructions, your committee will endeavor to present this subject in a manner which will be chiefly explanatory of the features of the electrical side. It is thought that this method of treatment will be useful to the members, inasmuch as electric transmission of power is a new departure in mechanics. No apology, therefore, appears to be necessary for the inclusion of a few elementary definitions and for some suggestions upon the most suitable apparatus for shop plants.

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A comparison of the relative advantages of electric and shafting driving for shop use may be made under the following general headings:

1. Relative economy in cost of power itself.
2. Relative convenience of operation and installation.
3. Relative effect upon shop output and cost of labor.

Referring in detail to the scope of these considerations:

1. ECONOMY.—This has been taken to comprehend only the relative cost of operating the two systems, including expense for fuel, attendance, repairs, interest on investment and depreciation. It is the reason most generally advanced for the installation of electric power, but can only be the controlling one where the cost of power is a large proportion of the shop running expenses.

In order to compare the relative efficiencies of engine and electric transmission, it will be necessary to subdivide the character of shop plants somewhat. To do this completely would lead to endless complication, but for present purposes the typical plants are:

1. Shop plant in which each building has its own power plant.
2. Shop plant in which all buildings are furnished with power from a central source.

The manner of connection from the prime mover to the tools may be assumed, for an extreme comparison, in either of two ways, namely: (a) shafting method; (b) individual tool-driving method.

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Taking the first condition, the average efficiency from engine to tools for steam engine transmission is shown elsewhere to be 50 per cent; for electric transmission, under condition "a," the shafting losses will be reduced by splitting up long lines and by avoiding cross-belting, so that they will not exceed 20 per cent, or an efficiency of 80 per cent; and in the electrical elements, as before shown, the efficiency from engine to shafting is 65 per cent; therefore the final transmission efficiency will be, 80 × 65 = 52 per cent, as against 50 per cent in the purely mechanical method; or, practically, a stand-off. Under condition "b," much less shafting will be employed, and the electrical portion may also show a better all-day efficiency, under certain conditions, by the shutting down of idle machines — say, a shafting efficiency of 90 per cent and an electrical efficiency of 66 per cent, or a resultant of 60 per cent — showing a small gain for the electrical method.

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Taking the second condition and assuming an unfavorable condition for shafting transmission, as in case of a shop having each building with its own boiler plant and one or more engines, and compare this with a case of a central power plant for electric transmission to all buildings, the possible fuel saving in the latter arrangement will result first, from some small saving in power required for each individual building, as before shown, and second, from some very considerable saving due to the better efficiency of a large engine and boiler plant over that of several small ones. In extreme cases, where large condensing engines displace small non-condensing ones, and in large stations having a uniform load, the fuel saving may readily approximate 33 1-3 per cent, as is shown in an actual case cited elsewhere.

Attendance.

ATTENDANCE.—The item of attendance is made up of three classes of labor—engineers and firemen; care of shafting and belting; electrical repairers. In an electric system the costs can be reduced by consolidating the engine and boiler plants and by the elimination of large and heavy belts, large shaft bearings and the consequent danger from overheating, reducing labor probably one-half; but a new item of expense in care of electric machinery will be introduced, which will about offset the other items, leaving the whole attendance bill practically unaffected by the introduction of electric shop power in plants of any considerable size.

Repairs.

REPAIRS.—As to repairs of shafting and belting it is difficult to obtain accurate data, the record of these items being seldom kept separately in shop accounts. The records of one large establishment have, however, been examined by your committee and the saving found in these items, under the electric driving system, is found to be more than sufficient to pay for all repairs to motors and lines. Thus the conclusion seems justified that the repair item will not be materially different under either system of driving.

Interest.

INTEREST.—The remaining items of power-cost are depreciation and interest on investment. It is difficult to institute a fair basis of comparison between the first cost of an electric and a steam transmission plant, for the reason that the results sought to be accomplished by the former provide additional shop facilities, and are therefore not rightly chargeable in a substitution sense. Considering, however, the case of simple substitution in a single shop, where the power plant and arrangement and number of tools is retained as before, electric driving is certain to involve a largely increased first outlay—approximately double that for shafting method. But in a modern shop plant other considerations are the guiding ones in selection of the power system, such as the possibility of labor-saving devices, cranes, etc., and the greater cost of the electric system becomes a rightful charge against the advantages so obtained.

Dropping, therefore, any attempt to draw a strict comparison between first costs, it may be said that in estimating the total cost of power machinery it is usual to include an allowance for interest and for a sinking fund, with which to replace the plant when its utility is no longer on an equality with best practice. These items are generally figured together at 10 per cent on first cost, a sum amounting roughly to one-fourth of the total running expenses of the power system.

CONVENIENCE AND SHOP OUTPUT.—These considerations are so closely inter-dependent that they can best be referred to together.

Steam power plants, restrictions of

The ordinary shop plant with steam power transmission, both in the arrangement of building and of machines, is the slave to the limitations of this system; it must be laid out so that the shafting and engine connection is as direct and simple as possible; the machines must be compactly arranged in parallel lines, and the ceilings and columns designed with special reference to shafting supports. In other words, the tools must be installed with first reference to the application of power and not, as should be the case, with reference to handling the work to best advantage. Handling operations are of necessity largely by manual methods, and the shop buildings even must be located with first view to getting the power to them with the least awkwardness and expense.

While generalizing in this manner, your committee has not lost sight of the fact that handling and transferring machinery may be operated by other means than electricity, but it is equally true that devices of this nature are of limited practical application, and the broad fact remains that electricity is to be credited with ushering in a new era of labor-saving shop devices.

Electrical ransmission no restriction.

Electrical transmission places no restriction on the location of the machines, and each shop may be planned with a view to handling its product with least waste of labor and with greatest convenience of access to the tools. These may even be transported from place to place to the work; further, the partial or entire absence of overhead line-shafting insures better lighting of the shop and conduces to cleanliness. These factors promote cheerfulness and an improvement in both quantity and quality of output.

The clear head room permits the universal application of various forms of traveling cranes for serving the tools and for conveying operations, furnishing the most efficient means yet developed for increasing shop economy, and, as a means of communication between buildings, electric cranes and transfer tables have advantages over appliances of the same nature driven by steam and air.

Special appliances.

Special Appliances.—In these electricity shares a large field with compressed air. It must be admitted that air devices have up to the present time received most attention at the hands of the railway mechanic, a fact in large part due to the lack of practical knowledge of the electrical specialist and to the greater cheapness of air tools. With, however, the general introduction of electric shop power plants and the better acquaintance of practical men with the agency, an extensive application of electric labor-saving devices is certain to result.

Flexibility.

Flexibility.—The extension of a shop building or the tool equipment under the shafting system is generally a matter of much difficulty, and the attempt to add to such a plant often results in inconvenient crowding of the tools or to an overloading or complication of the shafting system, a fact which fully accounts for the extremely poor efficiency sometimes quoted for shafting transmission. In an electric system, on the other hand, great flexibility in extension is secured, as new buildings may be placed in any convenient position and additions made to the driving system without affecting the intermediate links.

Speed control.

Speed Control.—The ease of speed control between wide limits of certain types of electric motors is a valuable feature and will result in more frequently securing a greater adaptability of the tool to the work than is possible where a change in speed involves stopping the tool and shifting belts and gearing.

Increase in output.

INCREASE IN OUTPUT.—This constitutes, in the opinion of your committee, the chief claim of electric transmission to the attention of shop managers, and it follows from the previously mentioned facts, as, by the use of electric handling devices, the tool is quickly served with its work and the product placed in the most favorable position for operating upon and idle time cut down, and, by independent driving, the capacity is increased by reason of the perfect control of speed possible.

POWER REQUIRED TO DRIVE MACHINE TOOLS.

Data for power required for shafting and for certain tools may be found scattered through the transactions of various engineering societies, especially in the papers of Professor Benjamin, in the proceedings of the American Society Mechanical Engineers, 1896 and 1897, which give valuable figures; but the amount of exact information attainable anywhere is not very considerable. In the nature of things, figures for frictional losses in shafting must be exceedingly variable, and under the plan of connecting the shop power system to one main driving engine, there is no ready means of analyzing the figure of engine-indicated horse-power to determine the consumption of any particular section of shaft or of a single tool.

With the introduction of electric driving, however, the subject is becoming better understood, as it is a simple matter to connect a test motor to a shaft or tool and thus obtain figures from which to design a power plant for maximum efficiency.

Efficiency, electrical transmission plants.

ELECTRIC EFFICIENCY.—An electric transmission plant varies in efficiency as follows:

Generators	86 to 94 per cent.
Transmission lines	90 to 95 per cent.
Motors	78 to 90 per cent.
Total final efficiency	62 to 80 per cent.

The above are figures for full loads on the different elements and the variation arises from the difference in sizes of units employed and in line losses assumed. At partial loads the machine efficiencies will drop, but the line efficiency will increase, so that the resultant will be nearly independent of the load. In fact, it is generally possible to shut down many of the separate motors when operating the plant at partial load, and the efficiency of transmission may thus actually increase under such conditions. In an average size of railway shop plant a resultant all-day efficiency of 65 per cent from the engine to the motor pulley may be assumed.

Efficiency, steam power plants.

SHAFTING EFFICIENCY.—The average friction horse-power in heavy-machinery shops to drive belts and shafting, from engine to tool pulleys, as given by various authorities, varies from 40 to 55 per cent of the total power used, and perhaps the round figure of 50 per cent is as near the correct general average as the data will permit. Considering a separate shaft only, with compactly arranged tools, a better efficiency than the above can be

TABLE No. 1.—POWER REQUIRED FOR MACHINE TOOLS.

Tool.	Nature of Work.	Horse-power Required.				Remarks.
		Empty.	Light Load.	Full Load.	No. of Cutters	
70-in. wheel lathe	Wheel center	....	4.4	7.9	2	Light cut.
	32-in. wheel center	...	4.7	5.8	2	½-in. deep cut.
	56-in. wheel center	1.5	5.2	6.2	2	
Horizontal lathe	56 in. wheel center	....	4.3	7.1	1	½-in. deep cut.
Large double-frame planer	Two frames	11.0	....	21.6	2	½-in. deep cut.
Slotter, 18-in. stroke	Frames	2.3	5.0	10.3	1	Heavy cut.
Slotter, 12-in. stroke	Wrought iron, 6 in. thick	1.5	2.1	6.5	1	
36-in. planer	Frames	3.4	4.2	7.4	1	
		3.4	...	11.3	2	
Drill press	1-in. drill, wrought iron	.97	1.94	2.9	1	
	1½-in. drill, wrought iron	.97	1.92	2.2	1	
	2¼-in. drill, wrought iron	.97	1.94	2.85	1	
Boiler-plate shears	9/16-in. plate steel	3.5	6.0	19.0	1	
Boiler-plate rolls	11/16 in. by 10 ft. 6 in. long, steel	4.5	14.4	19.8	..	
Jib crane, 10-ton, 10-h.-p. motor	Lifting 10 tons	1.2	....	13.0	...	
	Lifting 7 tons	1.2	...	11.0	..	
Jib crane, 6-ton, 8-h.-p. motor	Lifting 6 tons	1.2	....	11.6	..	
Traveling crane, 5 ton	Lifting and carrying 4 tons	11.9	....	19.3	..	
Planer	Empty	3.4	....	....	..	
	1 tool	....	....	7.4	..	
	2 tools	....	...	14.0	..	
Shafting	Empty	15.0	....	....	..	
	6 planers	....	....	20.0	..	
	4 milling machines	....	....	26.0	..	
	2 lathes	....	....	30.0	..	
	1 buff wheel	....	....	34.0	..	
Planer and siding machine	6-in. oak flooring	8.0	....	32.0	..	Top and sides planed.
24-in. planer	12-in. yellow pine	2.5	....	11.0	..	Top only.
Molding machine	6½-in. yellow pine carlin	1.5	....	8.5	..	4 sides.
Daniel 30-in.-head planer	Oak tender end sill	3.7	....	8.8	..	Cut 8/16 in. off top.
3-spindle boring mill	Oak, 2-in. bitts	0.5	....	2.5	..	
Large tenoning machine	Oak end sills	3.0	....	7.0	..	3¾-in.x5-in.x10-in. cut.
Circular rip saw, 28 in. diam.	Oak, 9¼-in. by ¼-in. cut	1.5	....	20.0	..	
Band saw blade, 1½ in. wide	Oak, 12 in. thick	1.5	....	6.0	..	

assumed, and your committee concludes from a number of experiments with electrically driven line shafts that 20 per cent fairly represents the average loss in shaft and counter-shaft bearings and belts on the tools, or an efficiency of 80 per cent.

Some authorities attempt to express the actual horse-power lost in friction per 100-foot length of shafting and per counter-shaft and per belt, but while figures of this kind would be useful if approximately correct even, your committee has been unable to check them closely enough to feel warranted in quoting them.

As a rough guide in laying down shop power plants, it would appear that the horse-power of generating station required per man for railway shops will average about 10.4 horse-power.

Table No. 1 gives a few examples from tests of the power required to drive typical railway shop tools, both for iron and wood working. The greater number of these results for metal-working tools were taken from tests at the Baldwin Locomotive Works, and for wood-working tools from Pennsylvania Railroad Company's tests.

SUGGESTIONS UPON THE MANNER OF INSTALLING AN ELECTRIC TRANSMISSION PLANT.

Systems applicable.

SYSTEM.— Both direct current and polyphase alternating current systems are applicable for shop use, and each system has its advocates among electrical engineers.

For long-distance transmission, say one mile or more, alternating transmission is almost a necessity; for shorter distances, and in cases of isolated plants in compactly grouped railway shops, either the alternating or the direct current system can be employed without any practical disadvantages in waste of power in transmission lines.

Mechanically the induction type of alternating motor has great advantages in its simplicity and the absence of rubbing contacts. When it is said that probably 90 per cent of all direct-current motor repairs are to commutators and brushes, the importance of this statement is clear. A further advantage in the induction motor is the strong mechanical design of the revolving element. This is built up of heavy copper bars firmly bolted to cast end rings. The direct-current motor, on the other hand, is a complicated assemblage of small wires, made additionally weak by the necessities of insulation.

The disadvantages of the alternating-current motor are that very slow speeds are not practicable and the fact that it is essentially a constant-speed machine. For driving line shafting, a constant-speed motor is entirely satisfactory, but for independent tool driving a variable-speed motor has unquestionable advantages.

If the alternating system is to be adopted, it is important to specify that the motors shall be of the "induction" type, as this is the only variety which is at all applicable for shop uses.

A further element of importance in the alternating system is that of "frequency" or number of alternations of the current per minute. It is difficult to give a positive recommendation as to the proper frequency without qualifications. Realizing, however, the importance of standardizing apparatus, your committee venture to suggest the specification of "3,000 alternations per minute" for adoption in railway shop plants. Alternating motors of this frequency are now in general use and have the very great advantage of fairly slow speed.

oltage.

VOLTAGE.—Direct-current generators are built for 125, 250 and 550 volts pressure, which, allowing for ordinary losses in lines, corresponds to motor pressures of 110, 220 and 500 volts respectively.

The 220-volt direct current motor is practically the standard for shop purposes; the 550-volt motor is used for railway purposes, but this pressure is undesirably high for shop use. Incandescent lamps may be obtained for 220-volt circuits, or the more common 110-volt lamp may be used on such circuits by connecting two of them in series. A 250-volt generator, together with 220-volt motors, are therefore recommended for shop plants.

Alternating-current motors are wound for either 200 or 400 volts, and for similar reasons to the above, the 200-volt system is recommended.

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TYPE AND SIZE OF GENERATOR.—As between the direct connected and belted machines the relative advantages may be thus stated: The direct connected generator is more compact and more solid in construction, especially in small machines, due to the greater size of its parts. It is therefore more durable and somewhat more efficient on account of elimination of frictional losses in belting.

The belted generator has an advantage of cheapness in first cost, due to its higher speed, which means more output for the same amount of material; and the further fact, often of importance, its ready applicability to existing engine plants.

For generators of 75 horse-power or less, the belted machine answers every practical purpose, but above this size the purchase of direct-connected machine will be found an economy in all new plants.

In planning the installation of a transmission plant with small beginnings for running, say, one electric traveling crane, transfer table, turn-table outfit and a few portable tools, a 75 or 100 horse-power belted generator will be found a convenient unit size. It may be installed cheaply by belting from counter-shaft at the main shop engine, but it is altogether better to provide a separate engine, for the reasons that the electric drive may be needed twenty-four hours in the day for special work (such as roundhouse turntable), and it makes a good emergency power plant for portions of the shops working overtime. It may be also used at nights to light the roundhouse and other buildings. When the transmission plant outgrows the capacity of this generator, it may still be used as a "spare" or for overtime work.

In laying out a complete system of electric transmission to displace engine and shafting transmission, careful attention should, of course, be given to selection of unit sizes. Little advice can be given offhand for such a case, as the determination of average and maximum loads is the basis of all calculations. In large plants, say of 500 horse-power or over, there should be two, and possibly three, units of the direct-connected type and selected so that the engines shall run as far as possible at economical loads, and that one unit may be out of service for repairs.

Calculation of generator capacity required can be made approximately from published data on power required to run machine tools. It is usual to install motors having a considerably larger nominal capacity than figured requirements, so that generator capacity need never be as great as the added capacities of motors attached. In fact, the generator load in an ordinary shop seldom runs above 50 per cent of that of the combined motor capacity, and in shops having a large motor load the effect on generator of running a traveling crane, a transfer table and turn-table need not be considered, as the momentary overload capacity of the machine will be ample to take care of such requirements.

Generators, rating of.

RATING OF GENERATORS.—Generators are sold with a guarantee to deliver their rated capacity, when driven at a certain speed, indefinitely, with a maximum temperature rise, due to electrical losses, of an amount supposed not to be injurious to insulation. This rise should not exceed 40 degrees centigrade above the temperature of the surrounding air. They are also guaranteed to carry an overload of 25 to 50 per cent for two hours, and short-period overloads of 100 per cent without injurious heating, These guarantees have led to an objectionable but common practice of figuring the engine size on the overload capacities; that is, it is quite customary to couple a generator to an engine having its economical rated capacity equal to the 50 per cent overload capacity of the generator. The consequence is that load is piled on the generator as long as the engine will pull it without seriously dropping off in speed, and an expensive generator is finally ruined for lack of the common-sense precaution which would be furnished by a properly adjusted engine unit.

Motors, types of.

MOTORS.—If the direct-current system be adopted, a wide range of selection in motor types is possible.

For line-shafting, motors should be of the shunt type.

For individual tool driving, the shunt motor is also in most common use; but the compound-wound variable speed motor is recommended as a desirable substitute. In fact, it is the belief of your committee that one of the great advantages of electric driving is in the possibility of simple speed regulation for large tools, and the attention of the electrical companies should be called to the importance of filling this requirement in their line of standard motors.

Motors are preferably of "open" construction; that is, with the ends of field frame uncovered. Where exposed to the wet or to mechanical injury from articles falling into it, the closed type of motor may be employed, but this type is not desirable where it can be avoided on account of its lack of ventilation, which means overheating unless the motor is of relatively large size for the work to be done.

For traveling cranes, hoists, transfer tables, locomotive turn-tables and boiler shop plate rolls, which start under load, run at variable speed, stop and reverse, the series-wound motor is the best, and is preferably of the enclosed style, which allows of more universal connection in any position, by gearing or otherwise, than the open type, and the question of heating is not so serious, on account of intermittent running.

For alternating motors, the same considerations as for the "direct" apply; but, as elsewhere explained, variable speed running in this type for tool-driving motors is not practicable. For crane work, however, the induction motor is successfully applied by attaching special controlling devices.

In selecting motors, the importance of keeping down the number of sizes should be had in mind. This should be done at the expense of some increase in first cost and in spite of some waste of power due to reduced efficiency of underloaded motors, especially as their reliability is thereby enhanced. Competition among the makers of cheaper grades of motors has resulted in giving ratings dangerously close to the maximum safe working limit, and with all motors a reduction in the working load greatly increases their durability.

In deciding upon the make of motor to be purchased there is the same range for selection as found in other lines of machinery; but as an electric motor is a somewhat delicate machine, it is important to select only those made by reliable manufacturers. Such can be had of several companies, but they are not the lowest in first cost, and, in absence of definite information, it is generally safest to avoid very cheap machines. Even the best manufacturers make motors with different ratings as to speed and heating limits, and the lowest speed and lowest heating limit motors should be selected. This latter should not exceed 40 degrees centigrade rise above external temperature at continuous full load run. The speed should be the so-called "slow-speed" variety. Table No. 2 gives about the proper speed for each of the standard sizes of shunt motors. It also gives the approximate selling prices of the list, based upon the highest grade machines; price includes motor, with pulley, base-frame and belt tightener, and starting box.

A corresponding list of "medium-speed" motors may be obtained, the speed for a given power being about 50 per cent higher than given in table, the prices being about 20 per cent less on smaller and 35 per cent less on larger sizes.

TABLE NO. 2—SPEED AND PRICES OF SLOW-SPEED DIRECT-CURRENT MULTIPOLAR MOTORS.

RATED OUTPUT, H.-P.	SPEED, R. P. M.	PRICE.	PRICE PER H.-P.
2	1,200	$135	$67
3½	1,050	190	55
5	950	240	48
7½	850	310	41
10	750	400	40
15	650	500	33
20	600	600	30
30	575	850	28
40	550	1,050	26
50	550	1,200	24

Tool driving.

MANNER OF TOOL DRIVING.—This varies in accordance with the motor arrangement and may be by

(a) The group system.
(b) The individual system.

The selection of one or the other system depends upon the size of the tools and the consideration of intermittent or continuous running. In general, where the tools require less than three horse-power each, it is best to drive them in groups from short-line shafts, which, as a rule, should not require more than 25 horse-power per shaft group. Where, however, three horse-power or over is required, or where variable speed or intermittent running is desirable, each tool should have its own motor.

In the group system the motor may be either belted to or direct-connected on the end of the line shaft, accordingly as space or plant cost permits.

In individual driving either belted or geared motors are employed. The belted arrangement is somewhat clumsy, but reduces shock and prolongs the life of the motor, and is, in the opinion of your committee, the better arrangement for general use.

CONCLUSIONS.

Conclusions.

1. In a small shop, consisting of practically one building, having an equipment of small tools for light work only, electric transmission will not be found a paying investment. In such a shop, however, an electric lighting dynamo will be a convenience, and may be utilized to run a few labor-saving electric tools, such as a cylinder-boring outfit, a turn-table motor, etc.

2. In an extensive railway shop plant the installation of a central power station and electric transmission will always be found advisable, as it will not only result in the most economical system in respect to operation,

but will make possible far more important shop economies, namely, an increase in quantity and quality of output and a reduction in cost of handling the same.

Respectfully submitted,

George Gibbs, Chairman.
F. Mertsheimer,
William Renshaw,
W. A. Nettleton,
R. A. Smart,
Committee.

Philadelphia, Pa., May 26, 1900.

APPENDIX A.

DESCRIPTION OF ELECTRIC TRANSMISSION SYSTEMS.

Electric transmission systems.

Power may be distributed by either of two electrical methods: First, by "direct" or "continuous" current, which means a flow of current in one direction along a wire; second, by "alternating" current, or a reciprocating flow analogous to the to-and-fro movement of an engine piston. Both of these systems are in general use for power and lighting purposes. The development of alternating current apparatus is in consequence of the limitations of the direct-current system when applied to long distance transmission, these limitations arising from the great cost of the large conductors needed to carry the low-pressure current, which is a necessary accompaniment of direct-current transmission. In the alternating system, on the other hand, electricity may be generated and transmitted at high pressure and consequently small volume, over a small line wire and transformed at the place of use by a simple piece of apparatus into current of low pressure and large volume. The alternating system is also used for local plants in which no long distances are involved and only low pressures are used.

The main elements of an electrical transmission system are as follows: First, the generator or dynamo, which produces electrical energy from mechanical; second, the transmission wire for carrying the current; third, motors for converting electrical into mechanical energy at the points where it is to be used.

Generators, description of.

The Generator.—This piece of apparatus is in general appearance probably familiar to all. It consists of a stationary part with bearings, and a revolving part, the shaft of which is connected to the source of power. One of these parts constitutes the "field," and is provided with magnet poles, while the other constitutes the armature in which the currents are induced by the rotative movement of its wires in the strong magnetic field.

Generators may be either of the "belted" or the "direct-connected" type, in accordance with their method of coupling to the engine shaft. The latter method is rapidly superseding the former for machines of about seventy-five horse-power and larger, as the type has many mechanical advantages over the belted machine.

The size of a generator is expressed in terms of its electrical output in "watts," an expression meaning the product of the volts pressure by the number of amperes of the current. As, however, a watt is an inconveniently small unit, it is customary to rate machines in a multiple called a "kilowatt" (K.W.), which is 1,000 watts, or about one and one-third horse-power.

Generators are further classified by the character of the current furnished into "direct-current" and "alternating" types. They are similar in appearance, but differ in the important particular that a direct-current generator is provided with a "commutator" and brushes for rectifying the alternating current produced in the armature, while the alternating generator needs no such device, the current being taken off from continuous collector-rings. An alternating generator requires, however, that its magnets be supplied with continuous current; this is usually done from a small separate machine, called an "exciter."

Alternating-current generators are further subdivided into "single-phase" or "multiphase," terms which refer to the kind of alternating current produced. This can best be explained by a mechanical analogy: An engine shaft may be driven by a simple crank, or by two or more cranks set at, say, 90 degrees or 120 degrees, the turning moments at each crank rising, falling and reversing in succession. In the same way, alternating currents may act in a simple wave or in several waves acting successively. The advantages of multiphase-current apparatus lie in the peculiar properties of motors which are possible with the system.

Generators are provided with a "switchboard," usually a marble or slate panel, on which is mounted safety devices, measuring instruments, and switches for electrically connecting it with the various lines of wire leading to the points at which the current is to be utilized.

Wire.

THE LINE.—The line consists of wires of different sizes or current-carrying capacities. These wires are covered with an insulating compound, and must be carefully laid out and erected under competent supervision in order to insure safety from fire and to avoid waste of power. It is essential that no considerable changes should be made either in the location of the motors or lights until the effect upon the distributing system is figured. The materials to be used and the manner of running the distributing lines is thoroughly covered by printed rules issued by the electrical societies and by the Board of Fire Underwriters, and an inspection certificate by the expert of the local board is desirable as an insurance against bad work and as evidence in case of fire.

The size of the wires is determined by two main considerations: First, the safe heating limit with the amount of current to be carried; and second, the loss of power entailed by the heating. The heating limits for different size wires are given in printed authorities, but the permissible drop of pressure or loss to be allowed within the heating limits is the matter to be determined by the individual. If this drop of pressure is made very large the loss of power is great and the cost of fuel accordingly increased, but the investment in copper conductors is small, and vice versa. As, however, an excessive loss interferes with uniformity of pressure in various parts of the distributing system, it is seldom advisable to allow more than ten per cent drop from the generator to the motor, which means that ten per cent of the current generated is lost in heat in the wiring system.

Distributing system.

The rules for laying out a distributing system, for either direct or alternating current, are the same; but the alternating-current distribution involves more complication than direct current, thus: In the direct system two wires constitute a feeder line, namely, the outgoing and the return; in the polyphase alternating system, which is generally used for power work, either three or four wires are needed for each feeder line. If a change in pressure of the alternating current is required, an additional piece of apparatus called a "transformer" is inserted in each feeder line. This device is permanently placed in a sealed iron box, outside of the building, or in such place that the high-tension wiring is entirely out of reach of accidental handling. It has no moving parts and needs no inspection except in case of accident.

Motors.

THE MOTOR.—An electric motor is a generator with the operations reversed, and both are of similar construction electrically and mechanically. It may be used interchangeably as a generator, although a slight modification is desirable in so doing. It converts electrical energy into mechanical by means of magnetic attractions or pulls.

Motors are divided, as in the case of generators, into the alternating and the direct types. These may be similar in general appearance, and both have the same main elements, namely, a stationary and a revolving portion, constituting the field and the armature respectively.

DIRECT-CURRENT MOTORS.—These are subdivided into two types, namely, "constant speed" and "variable speed." The constant speed, known as the "shunt" motor, runs, as its name indicates, at practically one speed independent of the load until it is severely overloaded, when it slows down, overheats and sparks at the commutator. The variable-speed motor may be of two kinds, the "compound wound," which may increase or decrease speed as desired with a change in load; second, the "series wound," in which the speed varies directly with the load and current. The series motor is the best known of the class and is most useful for crane work, electric traction, and all service where powerful "torque" or turning movement is required in starting, stopping and reversing a machine.

All types of direct-current motors require a "starting box" or a "controller" as the case may be. This is a resistance box of heavy wire designed to choke down the current and prevent excessive heating of the motor in starting until it reaches its normal speed, after which (in shunt motors) the current automatically adjusts itself to the power requirements.

Alternating-current Motors.—The only type of alternating motor in practical use is called the "induction" motor. In this type, brushes and commutators are entirely absent; in fact, the revolving armature has no electrical connection outside of itself. Current from the line is led to the stationary field magnets by three wires permanently connected thereto, making the machine electrically and mechanically of the simplest design. The induction motor is self-starting, simply by throwing a switch, and it tends to run at a constant speed independent of the load, and can carry a heavy overload without injury, provided the heavy load is not continued until the motor becomes unduly heated. It is adapted to the same uses as the direct-current shunt motor, but it may also be applied to cranes or other uses requiring frequent starting and reversal, in which case a special controller is required.

APPENDIX B.

EXAMPLES OF ELECTRIC SHOP POWER PLANTS.

Westinghouse Air-brake Company.— This large plant consists of a compact group of buildings, and is devoted to the manufacture of light apparatus by means of tools, each of which requires but a small amount of power, the manufacturing being conducted by a symmetrical arrangement of group-driven tools from line shafting.

The original power equipment consisted of central boiler plant of 2,000 horse-power, which furnished steam for heating and lighting, and to run air pumps, and thirty Westinghouse compound steam engines of 5 to 200 horse-power, placed in various departments and used to drive the line shafting. Although this system was well planned of its kind, the length of steam piping was necessarily considerable and the losses from condensation heavy. The great increase in business eventually overtaxed its capacity — especially in the matter of boiler power — and it was figured that the necessary relief for the boilers could be obtained through the superior economy of electric transmission. This was introduced under circumstances which make comparisons instructive. Twenty-three of the separate engines were replaced by three large condensing ones (Parson's Steam Turbines) of 400 horse-power each. These were placed in the engine-room adjoining the boilers, and each was direct-connected to a three-phase alternating generator running at 3,600 revolutions.

The power was thence distributed to fifty-six induction motors throughout the works. These motors have an aggregate nominal capacity of 1,050 horse-power, of which two, aggregating 250 horse-power, are used for pumps, etc., in the powerhouse, leaving 800 horse-power for shop power, as against 1,300 nominal horse-power of the twenty-three steam engines displaced.

The manner of connecting the motors is for group-driving of tools from sections of line-shafting, by belting to the motors placed on ceiling timbers or other convenient places. The original shaft sections were about 400 feet long, driven by an engine belted to the middle of the length; for electric driving, these sections are split up into four, with a motor for each. The motors are generally of 15 horse-power capacity, and drive the shaft sections at the most suitable speeds for the groups of tools connected. The shaft speeds were increased some 10 per cent under the new arrangement, and range from 110 to 170 revolutions per minute.

Thorough arrangements were made for comparative tests of results under the two systems of driving, this being accomplished by retaining temporarily all of the original steam engine plant and converting the system from one method of driving to the other during the testing period. Details of the test results can not be given in this place, but the general conclusions are interesting. These show a saving for electric driving during eleven and one-half hours' day run of 33 per cent of fuel consumed and about 40 per cent in amount of water evaporated. This fuel saving represents the commercial economy of the new system, and results from several causes, namely, reduced shafting losses, superior economy of large condensing steam turbines over that of the small non-condensing steam engines, elimination of condensation losses in steam piping, and better evaporation results from the boiler plant because of the less forcing of the fires.

CHICAGO GREAT WESTERN RAILWAY.—The new shops of this company at Oelwein, Iowa, were planned for electric driving throughout, the system being of the 220-volt direct-current type, with group-driven machine shop tools. The exhaust-steam method of heating is employed, using two fans, each driven by a 25 horse-power motor. An electrically driven transfer table furnishes means for all transferring operations, large and small, the shops being specially arranged to be served from this one table, which travels at a speed of 200 to 400 feet per minute.

The electrical energy needed in winter, including power required to drive the heating fans, is:

Average electrical horse-power, without lights	325
Maximum electrical horse-power, with lights	450
Night load	65
Nominal motor capacity, horse-power	450
Nominal generator capacity, horse-power	525

The generating station is arranged with three equal units of 150 horse-power, an unusually liberal amount of power for the capacity of the motors connected — a fact in part accounted for by the large percentage of power used to run the heating fans and for the lighting.

GENERAL ELECTRIC COMPANY'S SHOPS.—The enormous plant of this Company, at Schenectady, New York, is, as would be naturally supposed, equipped for electric driving, and represents their latest ideas.

In this plant the methods for driving of both light and heavy machinery may be studied. Small and medium size tools are in general driven by the group plan, the short lines of shafting being run by variable-speed motors mounted directly on the ends of the shafts, constituting a novel plan of driving without belting or gears, while large tools are driven by individual motors attached direct or by gearing.

A noticeable feature is the use of portable or shifting tools for very large work. These tools are provided with geared motors, the tool being moved to the work, instead of the work to the tool. This method is especially applicable for the machining of very heavy and bulky product, but may be used to advantage for special light tools in railway shops, as is pointed out elsewhere.

The entire shops are served by the indispensable electric power crane. These are, in the larger sizes, provided with auxiliary hoists operating at fast lifting speeds for light work.

Their system of wiring and the type of motors deserve special mention. The motors are of the direct-current variable-speed type, and the speed is regulated by a combination of two methods, as follows: The distribution is on the "three-wire" system, the two outside wires having a voltage of 250 between them, while the middle wire carries a potential difference of 125 volts from the other two. The motors are wound for 250 volts, and are connected between the outside wires to run at a certain standard speed; for a lower speed the connections are switched to one outside and one intermediate wire, operating, therefore, at one-half voltage. From this lowest speed to the normal one at 250 volts a gradual speed rise is effected by weakening the magnet strength of the motor field; and, on the 250-volt connections, the motor is further speeded up by again weakening the field. It is seen that these valuable properties of wide speed range are obtained in a very simple manner.

Examples of the speed variation possible in these motors are:

4½ horse-power motor runs at 400 to 800 revolutions per minute.
7 " " " " 250 " 500 " " "
12½ " " " " 150 " 300 " " "
15 " " " " 130 " 260 " " "

Baldwin Locomotive Works.—These works illustrate one of the earliest as well as probably the most extensive examples of electric machine shop driving. It is not too much to say that their manufacturing methods today hinge largely upon changes made possible by the use of electric power, and that no other agency could be substituted wholly therefor except at incomparably greater expense in space, installation and maintenance. In these immense works, situated in the heart of a large city and employing 8,000 men, the fullest utilization of space and the utmost simplicity and rapidity of handling operations are essential, and many ingenious examples of the convenience and economy of electric driving are here to be seen.

The electric plant is of the 250-volt direct-current type, the generators being direct-connected and aggregating 1,550 horse-power normal capacity. The motors are almost exclusively of the multipolar belted type, and number 320, having a total rated capacity of 3,500 horse-power. Only about 5 per cent of these motors are of the "series" type — an unusual condition, and due to the fact that the cranes are equipped with shunt motors.

About 950 horse-power at the powerhouse switchboard is required on an average to run the entire power plant, and this figure is fairly constant throughout the day.

Electricity was first introduced in the erecting shop for driving two 100-ton traveling cranes, and an immediate saving of eighty men in the laboring force was thereby effected. The possibility of this result is seen when it is noted that a crane is capable of lifting an entire locomotive, or the parts of same, thus allowing the erection of a large number of locomotives to be carried on in a contracted space and without interference or delays connected with manual handling operations. Hand-drilling operations were also largely reduced in this department by substituting electric portable drills.

In the wheel shop large economies resulted from electric driving. By remodeling the shop the overhead shafting was done away with, each lathe being equipped with a separate motor. The two long main aisles formerly necessary for handling the work in and out of the machines were utilized for additional lathes, giving about one-third more machines in the same floor space; and the shop was served by an overhead traveling crane, instead of the hand jib-cranes in former use. The result was a reduction of common labor force from forty men down to six, and a reduction of the time consumed in reloading a lathe from thirty to five minutes. The saving in power for this shop was also considerable, estimated at fully 50 per cent.

Similar results followed the introduction of electric driving in the frame shop, where the cutting out of overhead shafting and the use of traveling cranes enabled them to cut down the laboring force 60 per cent.

In all the above cases the use of cranes was made possible only by the electric driving of the tools to be served by them.

The motors are, in general, connected to large individual tools by belting from a self-contained counter-shaft and speed-changing drive mounted on a frame connected with the tool. Group-driving is employed for small tools from short-line shafts.

The cranes are of the single-motor type, having a shunt motor belted to a train of gearing and clutches. This type of crane is highly thought of in these works and is considered superior to the three-motor type in its smoothness of action, ease and accuracy of handling and reliability. It is, however, higher in first cost than the latter type.

The cost of electric power at these works has been estimated at about $1,200 per week, which sum includes cost of fuel, engineers and firemen, labor and material for repairs of powerhouse, lines and motors. It also includes interest and depreciation on first cost of plant. It is interesting to note that this entire amount is about 1.2 per cent of the shop pay-roll.

THE PRESIDENT: Gentlemen, what is your pleasure with the report?

A MEMBER: I move that it be received.

The motion was carried.

THE PRESIDENT: The report is now before you for discussion.

MR. HENDERSON: This is a very interesting report and it gives us information in a very concise form which it would otherwise take us some time to study, and I think that the thanks of the Association are certainly due to the committee for the manner in which this has been presented.

There is one point, though, on page 2, which it may be that I do not fully understand, but it seems to me in the way in which I do understand it that there must be something a little out of gear. Near the bottom of the page it says that the whole attendance bill will practically be unaffected by the introduction of electric power in plants of any considerable size. Now in an electric transmission plant which we are installing (and of course we cannot speak positively, because we have not got it in operation), in looking over what reduction in the way of attendance we could make (this plant is to take the place of seven isolated steam plants), even considering the necessary care of motors, etc., it has appeared to us that we will be able to make quite a reduction in the attendance. It may be that I do not understand exactly this clause. I think we have all been under the impression that by introducing a central electric power station for distribution that the interest on the first cost would be returned in the saving very largely from the attendance. I would like to ask Mr. Gibbs if my understanding is incorrect in that respect.

MR. GIBBS: There is always some danger in generalizing, as the committee did in that paragraph, because local conditions will affect the conclusions somewhat, but in order not to go into too much detail we had to select average conditions. It is easy to imagine the case of a plant having a number of separate engine and boiler plants, for which a single plant can be substituted, thus reducing the attendance item greatly, but in our report the item is taken to include all classes of attendance, that is, engineers, firemen, men who take charge of the shafts and belting and also electric repair men taking care of the lines and motors; and in most shops, except the most extensive ones, the number of engine plants is not reduced, so that it is merely a question of shifting around of the attendance and the net cost is not materially altered in this respect.

THE PRESIDENT: Gentlemen, this is one of the most important questions we have up for discussion and I believe there are a number of the members present here who could give the Association some valuable information on this subject. I would ask that we have a full discussion of this question.

PROFESSOR GOSS: Mr. President, I think the charm of this report is the candor with which the subject is treated. It really is a most inspiring document.

It has often happened that papers upon this and kindred subjects have been considered from the point of view of the specialist. The electrical engineer finds so many avenues between which to choose that when he attempts to write a general paper he is quite likely to concern himself with the details of certain systems or arrangements, and the reader fails to get the broader view. The committee has been remarkably successful in avoiding all such difficulty and has given us a depth of view and an unprejudiced judgment concerning fundamental principles which is altogether inspiring and helpful. I want to thank the committee for the paper.

THE PRESIDENT: I believe the value of this report depends on the fact that the chairman of the committee has been on both sides of the question and has looked at it from both sides, and for that reason he has been able to make an unprejudiced report.

MR. DEEMS: Mr. President, at the bottom of page 3 mention is made of the advantages of the electric transmission on account of the universal application of cranes, etc., due to the head room being clear of belts, shafting and other interferences. I think many of us who have not had practical experience with shops where there is an electrical installation of this kind do not appreciate fully the advantages of this one item. I have been impressed in going through shops where electrical transmission is used with the great advantage of being able to use cranes of any and every kind without interfering with belts and other things in the upper part of the building. That is one item I think is sometimes, in fact very often, overlooked in connection with this question.

Prof. R. A. Smart: I think the Association is to be congratulated upon having this report presented to it and I can say so with perfect candor because I, for one, was able to contribute but little to the preparation of the report. I feel that it is an honor to have my name attached to the report because it is such a good one. There is one point mentioned on page 1 which will stand bearing down on a little and that is the statement that economy in the installing of electric power is to be found more largely in the advantage of increased output and a saving in the cost of labor than in economy in the production of the power. Most of the writers who have handled this subject have dealt rather largely with the cost of generation of the power, and have neglected to place the importance upon the increased shop output that it deserves. This point is only mentioned in this report, but it is an important fact, one of the most important brought out by the report. It seems to me that the report places the problem before the Association in a very fair and impartial manner. It gives the facts to be noted upon both sides in considering the installation of electric transmission, and places the Association in a position to judge between the relative merits of different methods of transmission. It is seldom that a report on this subject can be written from such a fullness of experience as this one. They are generally written from the standpoint of one who has used one or another method or sometimes from the standpoint of one who is a particular advocate of a special method. This report is, however, written in an exceptionally clear and impartial manner.

Mr. Gillis: Mr. President, we are going to run our shops with electric power. We have already made some progress in that direction, and are now running several shops in that way. One of the first questions which came to my mind when I first thought of using electricity was the possibility of failure of the motors. That, no doubt, was due to my ignorance of the subject; but I think it is a question which naturally arises to many of us who are not thoroughly well posted on electricity and on the great improvement that has been made in the manufacture of electrical machinery. I would like to say for the satisfaction of those who are in doubt about the practicability of motor drives that I was told the other day by a representative of one of the best electric companies in the country, who visited our shops, that we had the poorest motors that were manufactured, and those motors have not cost us one cent for repairs since we installed them. We have had about twenty-five or thirty of them in use for from six months to a year. Of course I do not refer to renewal of brushes, lubrication, etc., but to important repairs. I do not know what we would do if we had the other company's motors; I think it likely we would declare a dividend. The point I want to make is that there is no reason for anyone having any anxiety about the reliability of motors. If anyone will stop and study the great advantages of electric driving, they will not be able to put in their motors fast enough.

There is one point which I took up with one of the electric companies that I think was not mentioned in this paper — the question of the great advantage of using a current of 500 volts instead of 220 volts, which we use. We have not looked into it carefully and cannot say what we think about it. In fact I doubt if our opinions are worth much anyway, because this is a subject upon which we are not thoroughly well posted.

There is this advantage in setting machinery. There is hardly any of us who has not at some time wanted to set a machine in a position of advantage for doing work or for handling material, and has been unable to do so on account of the limits imposed by belts and shafting. Where it is directly connected you can place the machine in any position or location you please. If you wish to work on a heavy piece you can take the machine directly to the work and if necessary set it on the work and connect up in a very short time. Motor drives have special advantages where it is desirable to place machinery under overhead cranes.

I do not understand the statement in regard to the relative cost of electric power and steam power. We know that the cost of steam power varies greatly in different plants. Some plants generate power very economically indeed, while in others the cost of power alone is sufficient to bankrupt the company.

But we have been informed and believe that there is a great economy in the use of electric power, not in the net cost per horse-power, but in a reduction of the total power required. In most shops you are running long lines of shafting, a great many running them continuously; whether your machines are on or off, all your belts are running, and the cost to drive shafting and belts is a large percentage of the total power to drive machines, in some instances being as great as fifty per cent. With electric power you have your machines divided up in small groups, and large machines run by separate motors. This permits the shutting off of the power at the machine, and we have been led to believe it would effect considerable economy. I would like to ask Mr. Gibbs if my understanding is correct?

MR. GIBBS: I hardly know how to answer that question briefly. On page 2 generalizations are given as nearly as we could figure them out. It appears that in a shop of one main building where you install a generator and engine, in a single power-house, and run small tools from shafting as before, simply cutting up the shafting in shorter lengths, there is little saving of fuel on the average. If, however, the shop is one having few large tools adapted to individual driving by a motor on each tool, considerable fuel savings are possible from the fact that all tools are not needed at once, and the idle ones may be cut off from the lines. An example of a fuel saving due to another cause is seen in case of the Westinghouse Air Brake Company's shops, referred to in the appendix. A saving of about 33⅓ per cent in power is shown, due very largely to the substitution of large condensing engines for some thirty small and scattered non-condensing ones. In this shop the tools are all small, adapted for turning out light product, and they are practically all in constant use, so that all economy came entirely from suppression of losses in transmission.

But I think it is not generally understood that in an electric transmission system there are also serious losses, due to the falling short of one hundred per cent efficiency in each of the different elements. On page 6 these losses are given as running from ten to fourteen per cent in the generators, five to ten per cent in the line wires, and ten to twenty-five per cent in the motors. Thus, the added losses show somewhere about thirty-five per cent from the engine pulley to the tool countershaft under average conditions.

But, looking at another phase of the subject, it is stated in the report that the Baldwin Locomotive Works estimate the total cost of their power at 1.2 per cent of the shop pay roll, this sum amounting to about $1,200 per week. The chief items of this cost which are reducible by transmission economies are the power-house labor and fuel accounts, as the other items are increased by electric transmission. On the whole I should say the total figure might be varied ten per cent, making a possible reduction of $120 per week. But consider, now, the *other* economies following the use of electric power in this plant; first, the reduction of laboring force in handling materials — not less than $1,800 per week; second, the increase in output due to more rapid handling of their product — an indefinite but large sum; third, the better adaptation of their building and ground to their manufacturing needs — a condition (in this case) vitally affecting their manufacturing methods. These considerations, it is seen, entirely overshadow the one of fuel economy, and are the ones the committee desired to bring out in the report.

The President: Mr. Gibbs, I understood Mr. Gillis to ask the question as to the advantage of a high or a low voltage. I do not remember of your answering that.

Mr. Gibbs: I did not understand him.

The President: What was your question, Mr. Gillis, as to the advantage of 300 or 500 voltage?

Mr. Gillis: I said that it had been mentioned to us, that there was a considerable advantage in the 500 volts or a higher voltage than mentioned — 220 volts. The electrical engineer who called our attention to this said that in his opinion the 500-volt current would be the one we would come to shortly.

Mr. Gibbs: On page 7 some recommendations are given as to voltage and I want to say again that these are generalizations. There may be conditions where other voltages or other sizes of machines would be better, but unless the electric salesman can give very good reasons for departing from those recommendations, I believe they are pretty safe as a guide. As to 500 volts versus 220 volts, in the 500-volt system something is saved in the cost of wire lines, because the higher the voltage the smaller the wire; on the other hand, the 500-volt motor is not a practical one for shop use. While this voltage does not necessarily kill a man, it gives him a very bad shock and in continuous-current motors the brushes give trouble.

Mr. Gillis: I am very much obliged to Mr. Gibbs. I think I understand the matter better. I think I possibly understand why the power company prefers the 500-volt motor. They have to bring the current to us about a mile and a half, and it would effect considerable saving in the transmission.

Mr. Sinclair: Mr. President, there is one of the electricians of the General Electric Company on the floor today who is celebrated for his knowledge of electrical machinery. I think it would be a good thing for the Association to invite him to address the meeting. I refer to Mr. Mullen, of the General Electric Company.

The President: Can we hear from you, Mr. Mullen?

Mr. Mullen: Mr. President, I thank you for the opportunity, but I think it would be more interesting to the gentlemen to hear from Mr. Rohrer, the electrical superintendent of our works at Schenectady, who can tell you about the practical part of it.

The President: We will be pleased to hear from Mr. Rohrer.

Mr. Rohrer: Mr. President and Gentlemen of the Convention,—I am laboring under the misfortune of only having glanced through the paper that has been read, and as I have just entered the hall, I do not know what the general line of the discussion has been. I would say this, however, that as between the use of small engines for distributing power against electric motors, there cannot be very much discussion. You gentlemen are familiar with the losses incident to carrying steam a long distance, so it is not necessary to bring that up. We have at the Schenectady Works about five hundred motors distributed over the one hundred or more acres covered by buildings, 450 of which are used for manufacturing purposes. The remaining ones are used for experimental and testing work. It might be interesting to give here the number of motors of each capacity used. They are as follows:

34	1	horse-power	motors.	30	20	horse-power	motors.
21	2	"	"	4	25	"	"
38	3	"	"	17	30	"	"
22	4	"	"	8	35	"	"
25	5	"	"	12	40	"	"
33	7	"	"	5	50	"	"
39	10	"	"	5	60	"	"
7	12	"	"	1	125	"	"
33	15	"	"	1	225	"	"

In addition to the above there are 115 motors of the railway type used on cranes; 204 of these motors are direct-connected to tools or shafting; 116 are belted and driving individual tools; 85 are belted to shafting. Of course, being manufacturers of electric motors, we would be expected to take our own medicine, but at the same time we have gone into it quite extensively because it is a matter of economy, ease of operation and increased production. Where it is desired to have motors at variable speed, such as in the operation of cranes and in the operation of tools where you desire to vary the speed, the direct-current motor of course has greater advantages than the so-called induction motor, which operates on an alternating current circuit. We have gone into the use of variable-speed motors quite extensively in the large machine shop which we completed last year. I think some of you gentlemen have probably seen what we are doing in that way. We find it of decided advantage in the matter of production to be able to increase the cutting speed of tools up to the maximum. The machining qualities of cast steel vary quite a good deal with different castings and it is a matter of experiment sometimes to find just what is the highest cutting speed that can be used and keep your tools in good condition. By the use of a variable-speed motor the machinist is able to increase the speed until he gets the best results. As to the voltage of direct-current motors, that has to be determined largely by your conditions. In fact, I might say here that each problem of using motors has to be worked out in its own particular way as to capacity and method of drive. What would be the best way of solving one man's problem would differ from another, and the general arrangement, the voltage and the size of motors for driving your tools and shafting will have to be worked out as I say. The individual will have to see what his conditions are and do the very best thing. We use at Schenectady 250-volt direct-current motors. We have a three-wire system so that we are able to operate our incandescent lights and the motors from the same circuit. Our distances are not very great from the central power station, the maximum distance we transmit being about 2,000 feet, and in case of railroad shops I think perhaps 250 volts would probably suit many conditions. Five hundred volts can be used for the longer distances. I know a great many shops where they have been using 500 volts for a number of years and have had no trouble whatever. I do not consider this voltage dangerous at all. It is what you will find in every electric railway, where the men are working about the motors in car barns, have to be working over them, in fact, making it more difficult than a shop motor. I do not know that I can say any more in a general way that would be of interest to you.

PROFESSOR SMART: I believe the General Electric Company has equipped its shops with direct-current motors. I would like to ask the gentleman, What was the controlling reason for using direct-current motors instead of alternating-current motors?

MR. ROHRER: We have in use a great many cranes, and as I stated in the beginning of my remarks, it is a little easier to control the direct-current motor where you want to vary the speed, as in the use of cranes. Another reason was that the shops were built about thirteen years ago, and we began with the use of direct-current motors. Alternating-current motors had not come up, so that after having started with direct-current motors, we found it to our advantage to vary the speed of induction motors and put them on cranes, and that has been done; but I think from my own standpoint it is a little more convenient to use a direct-current motor. If we were to start today with new shops we would of course consider induction motors; whether or not we would put them in I could not say just now.

MR. FOWLER: I have just come in and I do not know but that the matter I wish to refer to has been touched on before. I think one of the best adaptations of electricity to shop work is the fact that it enables you to take your tool to your work rather than take your work to your tool. I was in a large shop some time ago where they were building very large engines and they had practically very small tools all through the shop. The engines were exceedingly large pumping engines. I will give two or three instances of what they did with the small tool. For example, in boring out the hole for the crank pin they had the small boring bar bolted to the shaft and the boring bar driven by an electric motor standing on the floor which was doing the work. The shaft was a 12-inch shaft and the crank-pin hole was about six or seven inches in diameter. In another case they had a very large base for the frames of an engine. They had formerly made it in three castings, each about ten feet across, and had been taking them to a large machine to do the work. In this instance they cast it in one piece about forty feet long, put a boring bar in position to bore the bearings and drove it by an electric motor standing on the floor, and the work was done thoroughly satisfactorily. Some large engines were being put up where the cylinders were erected in place and were about forty feet from the floor before holes for the cylinder studs had been drilled. They took an ordinary radial drill, such as most men would put on a strong foundation and bolt to the floor, hoisted it to the top of the engine, bolted it there in position and drilled all the holes for the studs forty feet from the floor with everything in position. In ship work they are using a great deal of electrical apparatus for repairing and doing the work about the hulls. They have a drill that is held at the side of the ship by a magnet, doing away entirely with the use of the "old man," and movable from one place to another instantly upon the cutting off of the current, and all that work is done exceedingly rapid, and it occurred to me that it would be a very valuable adjunct to a locomotive shop to have small tools of that kind that could be quickly fastened to an engine and driven by an electric motor standing on the floor. That would be especially desirable on the inside of a fire-box, for example, where you wanted to do some drilling. The drill could be held to the side of the fire-box by a magnet and the holes drilled out with great rapidity and with an absolute total saving of the time that is usually occupied now in setting up and fixing an "old man," which is certainly not always the most convenient thing to use.

MR. GILLIS: I was very much interested in what Mr. Fowler said about the magnet. I would like to inquire what the effect would be on a man working on a boiler if he got short-circuited in there in some way. That also brought to mind the fact that I had heard that at Homestead the Carnegie people had a large crane with a big horseshoe magnet and they send it around over their floor and pick the work up and drop it anywhere they please without any chains or hooks. It was only a question of how much magnetism there was in the magnet to tell how many sheets they would pick up. I was informed that they would pick up five or six, and then cut off a little current and drop one sheet, and if they wanted to drop two sheets they would cut off a little more current. I do not know whether it is in use or not. I would like to ask Mr. Gibbs about that.

MR. GIBBS: I think that is drawing it a little fine. I was instrumental in putting one of the first of those cranes in operation in the Illinois Steel Works plate mill five years ago. We used to pick up the large boiler plates with magnets, picking up two or more of them at once. With the exercise of a little skill we could drop one and perhaps two, but it was a ticklish job, and only done for exhibition purposes.

MR. DELANO: In a hurried trip through the General Electric Works yesterday at Schenectady I was impressed with the convenience of the use of motors in having an accurate measure of what each machine was doing. For instance, one large boring machine was boring steel rims for a fly-wheel and an ammeter was on the machine to show just the work done in cutting, giving a measure which, as this committee points out, it is very difficult to get in a belted shop; also will give important information as to the quality and homogeneousness of the material that is being machined.

On motion of Mr. Waitt the discussion was closed.

THE PRESIDENT: The next report is on the "Best Type of Stationary Boilers for Shop Purposes." As there are no members of the committee here, I would ask the Secretary to read the conclusions of the committee.

The Secretary read the conclusions of the committee. The entire report is as follows:

REPORT OF COMMITTEE ON BEST TYPE OF STATIONARY BOILERS FOR SHOP PURPOSES.

To the President and Members of the
American Railway Master Mechanics' Association:

To the Circular of Inquiry forwarded by the committee to the members of this Association, in order to condense the report as much as possible, replies from those representing railways only have been tabulated, although very valuable information was received from manufacturers of boilers, mechanical engineers and others. Of those answering:

Questions submitted.

Question No. 1. From your experience do you prefer locomotive type boiler with internal fire-box, return tubular boiler bricked in, or water-tube boilers?

Four prefer the return tubular boiler; four prefer the water-tube boiler; five replies advocate the locomotive type with internal fire-box; one favors both water-tube and locomotive type, and one favors all three types under certain conditions, governed by the size of steam plant.

Question No. 2. What experience with return tubular boilers in connection with superheated steam, and what advantages are claimed for the latter?

From the information received in answer to this question, it appears that comparatively few members have had any experience with the subject of superheated steam in connection with return tubular boilers.

Question No. 3. Please state kind of grates used, whether stationary or rocker, and the width of openings between bars or fingers of grates.

The number of replies received to this question were all of a widely diversified nature (as anticipated) both as to kind of grates and width of openings between bars or fingers of grates, which is governed by the kind and quality of the fuel used.

Question No. 4. The kind of fuel used, whether lump, nut or slack coal.

Replies received indicate that slack coal or small screenings are generally used and in some cases the cinders removed from front ends are mixed with the coal.

Question No. 5. Diameter and length of tubes and ratio of grate area to heating surface per horse-power.

Replies indicate that the size, capacity and type of boilers govern the length of tubes, the lengths ranging from 12 to 18 feet; and the diameter of flues is governed largely by the kind and quality of fuel to be used.

Question No. 6. The evaporation, showing number of pounds of water per pound of fuel used, of the different types of boilers such as you have had experience with.

Replies to this question bring out the fact that but a very few members of this Association have made any evaporative tests of the calorific values of the different kinds of fuel used or with the different types of boilers, and it is somewhat surprising to note from those who have made tests there is very little difference shown in the evaporative efficiency of the three different types of boilers mentioned, clearly indicating that while the tests mentioned were made with such facilities as they had at hand, yet not so thorough as should be done for correct data whereby this Association can place itself on record as recommending one or the other types, as it has heretofore been generally conceded that the return tubular and water-tube type of boilers are more economical on fuel than the locomotive type, with the possible exception of the Wootten type of boiler, which has a much larger ratio of grate area to the heating surface than is practicable to obtain in the various other types of locomotive boilers.

Question No. 7. Your experience with automatic stokers; kind, cost of installation and maintenance, and do you consider them a good investment?

All who have had experience with the automatic stokers recommend them highly.

The result of your committee's investigation is herewith submitted to the consideration of the members of this Association:

1. The governing factors for the preference of any particular kind of boiler for shop purposes depend upon the local conditions and circumstances; such as the size of the steam plant to be installed; kind of service required; steam pressure to be carried; available fuel supply; quality of water, etc., and, as there appears to exist

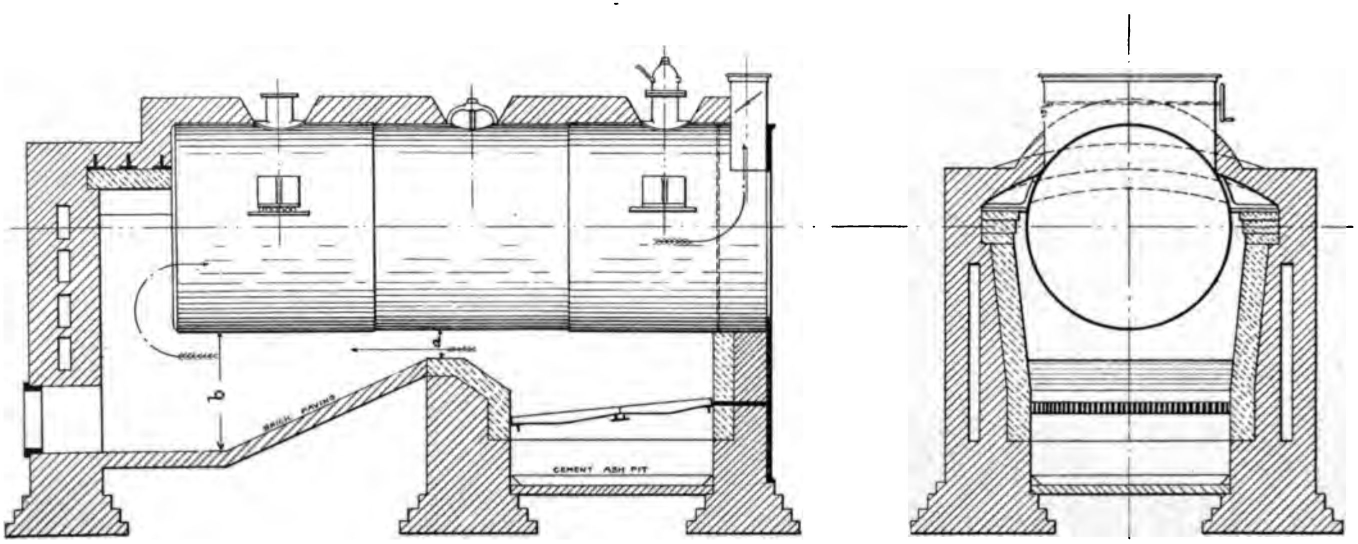
such a wide diversity of opinion and preference for either one or the other type of boilers as to their respective merits and advantages, it would be well to consider all of the above enumerated requirements which enter into the successful performance of any boiler before making the proper and most suitable selection. In the absence of any thoroughly accurate data of comparative economy tests of the different types of boilers, your committee herewith submits information on the various advantages and disadvantages of the different types of stationary boilers for shop purposes as obtained from the replies received from members, manufacturers, designers and other persons of experience in that line, together with their own observations.

Return tubul boilers.

For a medium-sized steam plant, such as is ordinarily required for a railroad repair shop, a well constructed and properly set horizontal tubular boiler with fire-brick lining gives very good and economical results under varying conditions of water, fuel and the average fireman, where the steam pressure to be carried does not exceed 125 pounds per square inch and simple non-condensing engines are to be used; as in a properly constructed return tubular boiler, similar in design to those shown in Figs. 1 and 2, the radial surface of the shell exposed to the action of the fire is accessible, and the interior can easily be kept clean, and the heating surface of the shell exposed to the fire does nearly fifty per cent of the total work of the boiler. Another advantage for the return tubular boiler for railroad shop purposes lies in the fact that a majority of the members of this Association possess the facilities for its manufacture. With this type of boiler the relative height of the brick wall as shown at "a" (Figs. 1 and 2) and the depth of combustion chamber as shown at "b," as also the distance of grates from boiler shell, should be governed, in a measure, by the nature of the fuel used.

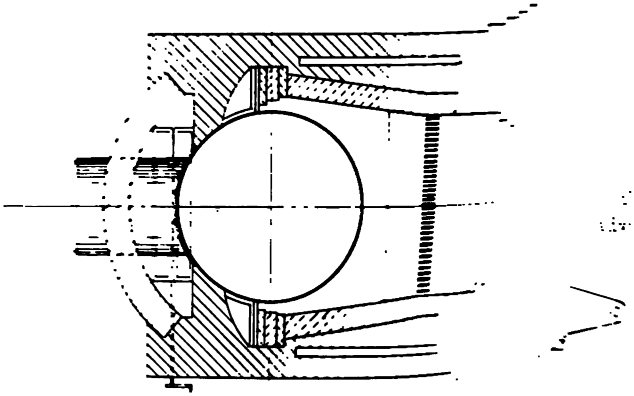
Water-tube boilers.

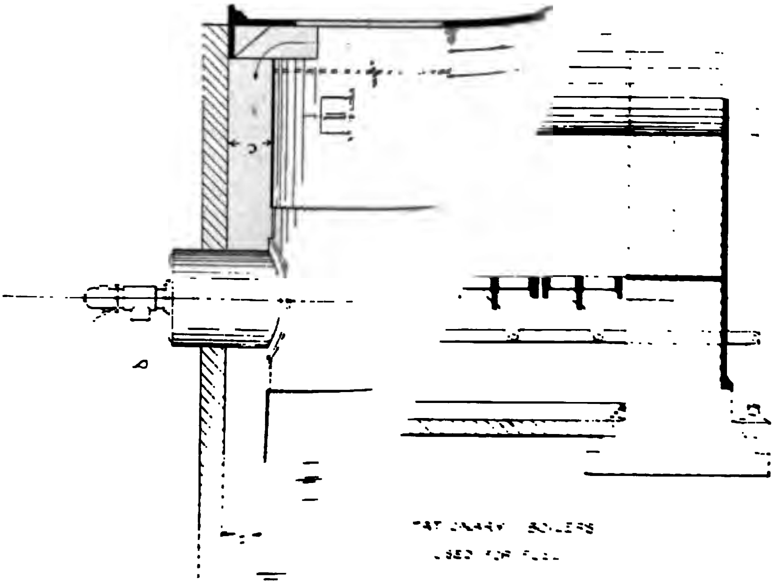
With water-tube boilers, the heating surface being almost entirely confined to the tubes, the insoluble salts are deposited and adhere to the interior surface of the tubes in spite of the vigorous circulation claimed for this type of boiler, but the introduction of soda ash and lime into the feed-water will, of course, act equally as favorable in this type of boiler as in the others in the prevention of scale forming, and while ordinarily it might be considered a difficult matter to keep such tubes clean, and that the cost of maintenance might be greater owing to the liability of the tubes leaking where set in the headers and uptakes, yet all reports received by your committee indicate the contrary when fairly good feed-water is used, and invariably those who have used this type of boiler mention it very favorably, especially the type having straight tubes (without bends) that are easily accessible at both ends. It is doubtful, however, whether the water-tube boiler can show much better efficiency than a properly designed and properly set return tubular boiler under all conditions. If, however, the magnitude of the steam plant is designed for compound condensing engines a properly constructed, first-class water tube boiler may be preferable to the return tubular for the reason that it is economical to carry steam at a higher pressure on compound engines than has heretofore been the practice with the return tubular boiler. It appears to be the prevailing practice at the present time, especially so in large steam plants, to use water-tube boilers capable of carrying a working pressure of 180 to 200 pounds per square inch in connection with compound condensing engines, as, with the water-tube type of boiler, its heating surface is considered more effective because of having the heating surface made of very much thinner material than is possible with the return tubular boiler designed to carry such a high pressure.



ORDINARY RETURN TUBULAR BOILER AND SETTINGS.

FIGURE 1.





[illegible]TATIONARY BOILERS
[illegible]USED FOR FUEL

[illegible] grade of coal which is suitable [illegible] metals. The [illegible] slack coal and the [illegible] of more [illegible] coal, but the [illegible]

[illegible]ly by local conditions [illegible] coal.

[illegible] inches in diameter. The [illegible] weight [illegible]

Another important point claimed for the water-tube boiler is its comparative freedom from disastrous explosions in comparison with the various other types owing to the subdivision of the water spaces into smaller volumes, or areas, and that repairs can be made much quicker on account of not having to wait so long for boilers to cool down as with the return tubular type, owing to the heat contained in the shell and brick settings of the latter; and the ordinary repairs in the former generally consisting in the renewal of a tube, header or uptake, which can be replaced in much shorter time than patching the shell of return tubular boilers, which quite often necessitates removing a portion of the brick settings. It seems to be generally conceded, however, that the return tubular type furnishes the drier steam.

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The locomotive type of boilers with internal fire-box deserves some mention on the following point of merit, namely, they are portable, which permits of their being easily removed from one point to another, and are a type with which the average shopmen are familiar and can readily make repairs, and it requires no expensive brick settings, taking up less room than either the return tubular or water-tube type, and the heat from the fuel is absorbed only by the heating surfaces of the boiler; whereas with the return tubular and water-tube type, the brick walls enclosing the boilers absorb and radiate considerable of the heat. However, your committee does not consider them as economical on fuel as the other types mentioned, for the reason that as a rule quite a portion of their heat-radiating surfaces are exposed to the varying conditions and changes of atmosphere, thereby causing loss of heat by radiation. They also require more attention in firing, owing to the limited grate area, and as a whole the locomotive type of boiler is much more expensive in construction and maintenance than the return tubular type and can only be recommended to be used as is the generally prevailing custom, namely, utilizing such boilers as a temporary expedient as are discarded from locomotives.

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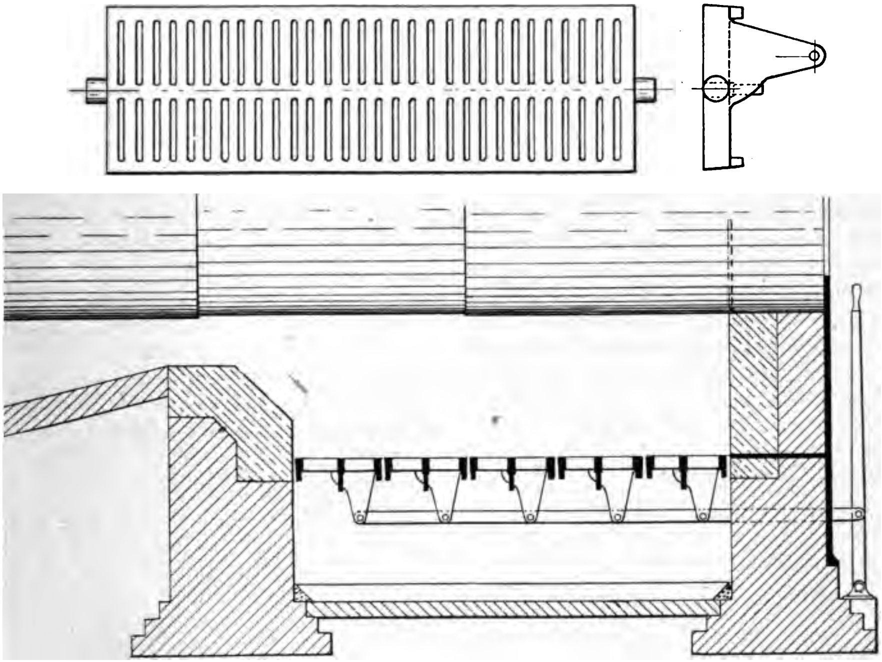
2. From the information received in answer to this question, the limited experience develops the fact that steam users do not generally appear to recognize the value of the properties and advantages derived from the use of superheated steam, and from the limited and hasty investigation made on this subject the conclusions reached are that the superheating of steam to a higher temperature than that of the saturated steam commends it to our favorable consideration in connection with the return tubular boilers whenever the local conditions will permit of the return tubular boiler setting being constructed for that purpose. The accompanying sketch (Fig. 2) shows the general method of construction, which may be followed in arranging the brick settings of the ordinary return tubular boiler for the generation of superheated steam, so arranged that the hot gases are permitted to return over the top of the boiler shell after leaving the flues instead of passing directly to the chimney. It is evident in thus returning the gases over the shell that any remaining calorific properties contained in these gases and products of combustion are utilized to some extent and are made to impart their remaining heating properties to the exposed surface of the boiler shell, whereas in the ordinary tubular boiler construction they are allowed to go to waste in passing directly through the smoke-stack. It would seem that the utilization of these otherwise wasted heat units should be a marked improvement, as superheated steam considerably reduces cylinder condensation and is otherwise effective in the comparative reduction of steam consumption in the engine. On the other hand, there is some liability of the plates becoming bulged from the intense

heat, and also soot lodging in the superheater as shown at "c c" (Fig. 2), but which can be readily removed by making provisions therefor; and, owing to the increased distance traversed by the smoke and gases, more draught is required which can be compensated for by increasing the height of the chimney.

Grates.

3. The kind of grates with the openings, etc., depends altogether on the kind and quality of fuel used, which, as a rule, is mostly slack, culm or refuse coal, and your committee is of the opinion that where a rocker grate can be used it is advisable to do so, and more especially so with the poorer grade of coal which is liable to clinker and carries a large per cent of ash and minerals. The box form of rocker grate as shown in Fig. 3 is preferable for burning slack coal and the ordinary locomotive finger type of rocker for lump and "run of mine" coal, but for burning wood the bar grate is more suitable.



BOX ROCKER GRATE FOR STATIONARY BOILERS
WHERE SLACK OR CULM IS USED FOR FUEL.
FIGURE 3.

Fuel.

4. Kind of fuel used, being governed entirely by local conditions; but, as stated in former paragraph, it is largely slack and refuse coal.

Tubes.

5. It appears that the general practice is to use tubes 3 inches in diameter for hard or anthracite coal; 3½-inch tubes for first quality bituminous or high-grade soft

coal, and 4-inch tubes for low-grade bituminous coal; the tubes being not less than 12 nor more than 18 feet in length. The ratio of grate area to heating surface for return tubular boilers with a natural draught, using ordinarily good bituminous coal as fuel, is about one square foot of grate area to 35 square feet of heating surface, and for water-tube boilers, with like conditions, the mean average ratio is practically one square foot of grate area to 45 square feet of heating surface; but with anthracite coal the ratio is somewhat less, and the mean average ratio of heating surface per horse-power averages 12½ square feet for return tubular boilers and 10 square feet for water-tube boilers.

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6. Bearing on the subject of evaporation of water per pound of fuel. The much regretted absence of definite information and results of evaporative tests of the calorific values of fuel used with different kinds of boilers compels your committee to formulate its own conclusions, from the limited information and data received in reply to the above question, together with its own experience and observations.

The different fuels throughout the United States vary in calorific values to a considerable extent as well as in their component parts, which influence their evaporative efficiency, so much so that a statement of the number of pounds of water evaporated per pound of fuel must always be made with reference to the kind of fuel used. Good return tubular boilers and water-tube boilers, when properly set and under ordinary running conditions, generally are good for seventy-five per cent efficiency of the calorific values of fuel; that is to say, they will utilize that percentage of the heat units evolved in the combustion of coal. The best American bituminous coals contain about 14,000 heat units per pound, and to utilize 75 per cent of these, 10,500 heat units must be absorbed into the water in the boiler. This is equivalent to an evaporation of 10.87 pounds of water per pound of coal from and at 212 degrees Fahrenheit, or 9.45 pounds of water evaporated into steam at 70 pounds pressure from a feed-water temperature of 100 degrees Fahrenheit. This is a high result from the best-known American coal. Ordinary Western bituminous coal averages about 12,000 heat units per pound, while low grade soft coal would be high at 11,000 heat units, so that the utilization of seventy-five per cent, or 8,250 heat units, would only result in 8.54 pounds of water evaporated per pound of coal from and at 212° Fahr., which would be equal to about 7.42 pounds of water from a feed-water temperature of 100° into steam at 70 pounds pressure. All this presupposes intelligent firing, tight and clean boilers. As the quality of coal deteriorates, the presence of clinker and ash has a deadening effect upon the combustible part in addition to the subtraction of combustible matter, so that with low grade coal the ratio of seventy-five per cent efficiency doubtless falls much lower.

On the above basis it is generally accepted that the hourly evaporation of 30 pounds of water from a feed-water temperature of 100° Fahr. into steam at 70 pounds gauge pressure to be taken as one horse-power, which may also be considered to be equal to 34½ pounds of water evaporated from and at a feed-water temperature of 212° Fahr. into steam of the same temperature, or atmospheric pressure.

The above reference is made simply to make plain the maximum evaporation that can be expected of the best type of boilers under the most favorable conditions with the various kinds of fuel.

okers.

7. Many questions enter into this problem, such as the number of boilers in a given steam plant; the character and price of coal; the necessity of burning coal

without smoke; the possible saving of labor, etc., and from reports received from the members and others having experience with them your committee infers that, with a plant of boilers requiring the services of more than one man to fire them by hand, the automatic stokers are a decided advantage both in saving of labor and economy in fuel; also in smoke consumption, providing a good type is used. Those that are recommended are such as will pass the fresh smoke of the coal over the light flame and will at the same time not be wasteful as regards dumping of unburned fuel, which is the case with some makes of chain stokers.

Conclusions.

In conclusion, your committee regrets that, owing to the limited time allowed not being sufficient to make as thorough an investigation and tests as the subjects warrant, it is not prepared to make any recommendations as to preference between the return tubular or water-tube type of boilers, and simply mention that either type is both efficient and economical under the conditions as mentioned in the foregoing report. The important factor governing either type is to have it of adequate capacity to meet the varying demands of the load without having to be forced to its maximum capacity, at which point any type of boiler ceases to be economical. It is also desirable to have as large a grate area as practicable within reasonable limits, to permit of burning slack or refuse coal, and the smoke-stack should be of ample area in both diameter and height, as a good draught and consequent greater heat tends to more perfect combustion, especially of the volatile part of the fuel, of which almost all American bituminous coals contain a large amount. The dome should be of rather small diameter and of proper height, or dry pipe from which to obtain a constant supply of dry steam. The dome, together with the boiler, should be well insulated with non-conductive material.

Another very important factor of which the members of this Association are cognizant, but which quite often is not given the attention its importance deserves, is the matter of keeping boilers, including the brick walls (of the settings), tight and free from leaks and the interior of the boiler as clean as possible under existing conditions, as a very small leak in the boiler will very often materially affect the evaporative efficiency, and the leak, if only a simmer, if allowed to continue, forms corrosion which eats the plates away and eventually necessitates the application of a patch, which could be prevented by a few minutes' caulking at the start. The boilers to be set as near to the engines as conditions and conveniences will permit, and, where circumstances are favorable, to also superheat the steam. A better circulation is maintained by introducing the feed-water as near the water level in boiler as is practicable without its first coming in contact with the direct heating surface of the boiler.

If your Association considers that the subject deserves further investigation to determine definitely the best and most economical type of stationary boilers, it might be possible to have a series of practical tests made at Purdue University by getting the manufacturers of the return tubular type interested to such an extent as to furnish a battery of that type of equal capacity to the battery of water-tube boilers now at Purdue; for to make a thorough and practical test all conditions must be equal, which can only be obtained by setting one battery of boilers adjacent to the other, using them alternately and with the same load, with similar fuel and water; or, if any of the members know of such a plant already installed, it is probable arrangements can be made with such firms or owners thereof to permit a thorough test to be made under the supervision of such persons as you may designate for that purpose. If such a test be made it should also include the superheating of steam.

Respectfully submitted,

J. F. DUNN,
J. J. RYAN,
JOHN HICKEY,
Committee.

SALT LAKE CITY, May 24, 1900.

On motion of Mr. Henderson the report was received and opened for discussion.

PROFESSOR GOSS: I have read the report with considerable care, but it was several days ago and I have since neglected to review it. I am naturally interested in the suggestion of any committee with reference to work which may be undertaken at Purdue. As I understand it, the committee suggests that comparative tests be made to determine the relative efficiency of boilers of different types. As a matter of fact there is, I suppose, considerable data on the subject in question and a review of these would serve the purpose which the committee has in mind.

Generally speaking, boiler efficiency is a function of extent of heating surface, and other things being equal, that boiler will be most efficient which has the most heating surface. The question as to whether a boiler should be of one type or another for shop use is largely one of adaptability, and not to any considerable degree one of efficiency, for when the type has been settled upon almost any efficiency within limits which are practicable can be secured by a proper choice of details. For this reason I am not inclined to give very great emphasis to the particular suggestion of the committee with reference to tests. A much larger problem and a more profitable one for experimentation, was raised yesterday in the topical discussion concerning the length of boiler tubes. That is a problem which might well merit the attention of the Association just at this time.

MR. HENDERSON: There is one point in this report to which I think exception ought to be taken. If the members will look at the picture on page 5 they will notice a little dimension "c" between the top of the boiler and the top of the setting, and on page 6 the committee makes the statement: " It is evident in thus returning the gases over the shell that any remaining calorific properties contained in these gases and products of combustion are utilized to some extent, and are made to impart their remaining heating properties to the exposed surface of the boiler shell, whereas in the ordinary tubular boiler construction they are allowed to go to waste in passing directly through the smokestack. It would seem that the utilization of these otherwise wasted heat units should be a marked improvement, as superheated steam considerably reduces the cylinder condensation and is otherwise effective," etc. Now I do not believe that it is possible that any superheating of steam can be obtained by such an arrangement, because to superheat steam we must raise its temperature above that of saturated steam and there can be no water present. Here it is suggested to superheat the steam in the upper part of the boiler and have saturated steam in the lower part. I do not think that is a possible condition. I may be wrong in that; but I think Professor Goss can enlighten us on that point.

Professor Goss: The manner in which that question is put makes it one of some delicacy. I have no doubt, however, that the effect of the arrangement described by the committee would result in very dry steam and, possibly, in some slight degree of superheating. The quality of steam can be changed after it leaves the surface of the water if sufficient heat is applied, even though it remains in the boiler. But heat must be applied to the steam. The common form of small vertical tubular boilers in which a considerable length of the tube is immersed in steam only, will deliver superheated steam.

But I do not think the arrangement described a good one. It is one that is occasionally resorted to, but is, as it seems to me, attended with some danger. It will be seen that a boiler set as described has heat given to the upper portions of the shell. Under normal conditions, steam circulating under the inside surface of the shell conducts the heat away. But in the process of firing up heat is given to the shell when there is no steam underneath and, consequently, when there is no medium to conduct it away, and the dangers ensuing from unequal heating and possibly, also, from actual overheating are considerable. It may be urged that the danger I refer to is lessened by the fact that the heated currents which reach this portion of the shell must first pass through the tubes of the boiler, where they undergo a reduction in temperature; and such an argument is not without force, but I do not believe the gain in efficiency is a sufficient reason for subjecting the boiler to the hard service and danger of injury which the arrangement implies. If there is a demand for superheated steam, a separate superheater should be provided.

This whole matter of superheating (which, by the way, is quite a different question from that under discussion, but I may refer to it briefly), has received a good deal of attention. In this country it was very carefully reviewed, investigated by Isherwood thirty-five years ago and the general conclusions which he reached have never been disputed. The difficulties, however, in producing and utilizing superheated steam under modern conditions of practice are many. We have raised the pressure of steam until the temperature of saturated steam approaches or even equals that of the superheated steam of Isherwood's day, and if we attempt to superheat to any marked degree the high pressure steam with which we now deal, the temperature becomes too high to be manageable. It is of interest, however, to note that at the present time the subject of superheating is receiving a good deal of attention both in England and Germany. At the locomotive works at Hanover, Germany, there was a locomotive exhibited designed for using superheated steam. In this engine a portion of the usual tubes had been omitted and in their place a large flue, say from ten to fourteen inches in diameter, had been inserted, and in this flue there was arranged piping through which the steam circulated in its passage from the boiler to the cylinders. A portion of the hot gases from the fire-box passed through the ordinary tubes and served to generate steam, and a smaller portion passed the large tube and in so doing circulated around the superheating pipes, increasing the temperature of steam already generated. The result of this arrangement was just what we should expect from the work with which we are familiar. There was considerable gain in fuel and steam economy; the results derived from a simple engine approaching those obtained by their best compound locomotives. But they discovered the same thing which Isherwood discovered, namely, that while superheating promotes the efficiency of an engine, it also serves to stimulate repair bills and, in the case of the locomotive referred to, I understand that increased cost of repairs due to the presence of the superheater quite equaled in value the saving in fuel.

On motion the discussion was closed.

THE PRESIDENT: The next question to be taken up is under topical discussions. It has been suggested that we take up the last question, No. 8: "How to Make Pooling of Locomotives a Success," to be opened by Mr. Rhodes.

MR. RHODES: Mr. Chairman, when I found my name attached to this topic, "How to Make Pooling of Locomotives a Success," I was considerably surprised. It is generally supposed that a party named for introducing a subject at least favors the method that may be under discussion. Now, as a matter of fact, I knew nothing at all about this subject being assigned to me until I got word from the chairman of the Committee on Subjects telling me that the subject had been named and that he had sent my name in to introduce it, and I want to make this explanation so that you will not necessarily decide at the start whether I am in favor of the general pooling of engines or not. In other words, I do not want to sail under any false colors. I thought yesterday, when we were discussing that very interesting paper on compound engines, how complacently we all assumed the responsibility for the large and growing increase of compound engines. I was fearing all the time that some supply man would come in and would say that we were robbing him of what was his due, and that it was to his mechanical methods with the vice-presidents and higher officials of our roads, that the introduction of so many of these compound engines was largely due. (Laughter.) Now, I want to have it pretty clear that whatever pooling of engines there is on the line that I am connected with is not of my doing. We get these things sometimes by inheritance, and as far as the pooling on the line that I am connected with is concerned, I have got into that by inheritance.

I like to think of the pooling of locomotives in connection with a livery stable. If I were running a livery stable, and if my patrons could afford to pay what I would charge them, I would have each individual own his own horse and never use it excepting when he wanted it, and I would care for it when he did not want it and charge him for it. If they could not afford that, I would not immediately abandon the livery stable business; I would suggest that each family own its horse and use it in the family only, not allowing any other individuals who were not connected with the family to use the horse. Now, if conditions got to be such that that was not profitable for the patrons — I would not run it if it was not profitable for me — I still would not abandon the livery business; I would propose something else and I would say: "Now, gentlemen, I propose to pool all the horses in my stable; I am not going to keep as many as I have kept up to the present time, but I don't know that you will suffer at all for I will supply nothing but the best service. It will inconvenience me a little because I shall have more difficulty in keeping up the condition of the animals that I am caring for and that you are not using, but I will try and give you as good service as you got when you each had your own horse." Most livery stables in the West are operated this way today and bring in a profitable return to their owners. This represents my views in regard to pooling engines. I think that the way that some of us have taken up the question of pooling is that we have jumped into the thing too quickly. It is a good deal like a question that has claimed such general attention recently, the oiling of equipment. I have been quite interested in the discussions that have taken place and have coöperated with others on our system in endeavoring to bring about a change in the methods of oiling, so necessary owing to the increasing speeds of our trains, and I have found that we made mistakes when we first went into it, largely from a misunderstanding. For instance, one of the moves that we made was to do away with all oil cans at oiling stations and with all oil cans on trains, both passenger and freight. We did not start it very rapidly, but what was the first thing that came up? No oiling was done at all. That is to say, the journals, in place of getting the individual attention that we thought it was so necessary they should get, and which they were not getting when we used the oil cans, now they neither got the individual attention nor the oil from the cans, and the results were not satisfactory until our men actually carried out the packing iron attention to journal boxes contemplated in lieu of the oil poured in the boxes from oil cans. I think one of the reasons why pooling sometimes is not a success, is those who are introducing it do not thoroughly introduce it; they leave some of the essentials out. One of the essentials often overlooked is the repairs. The enginemen, when engines are not pooled, always do a good deal of repairs to the engines. If you go into a pooling arrangement it is very necessary that you provide some one to do these repairs which the enginemen under the pooling system will no longer do. Then again, the cleanliness of the engine. The fireman does a great deal to keep the engine clean. If you are going to pool the engines, the fireman does not care about doing the work for some one else to get the benefit of. The result is with pooled engines you often find that they get into bad condition. It is very necessary to provide some one to do the cleaning which the firemen no longer do. Then, again, another very important part is the inspection of the engine. The engineer is careful to inspect and look after his engine, and when we take him off the engine the chances are that that matter is neglected and no longer gets the same careful attention from the engineer that it did when he only handled the engine, and it is quite important that an inspector be provided to do the work that the engineer no longer does or does not do as thoroughly, perhaps, as he might.

Another thing that I think is very essential in providing for these inspectors is, that we depend a good deal upon what the inspector finds on the engine and also what the engineer reports. I believe that what the engineer reports would be a little more important than what the inspector finds; but as a matter of fact, none of us like reporting a great deal. We are apt to overlook things. We do more by word of mouth than we do by writing it out, and I think that where engines are in a pool it is a very good plan to have the inspector meet the engineer on his arrival and board the engine and hear from him what has transpired during the trip and what he thinks needs attention. If that is done there will be a number of things that the inspector will discover and will hear of which he would not get through the reports.

Some one will say: If you are going to hire these cleaners and these repairers and these inspectors, where is your economy going to come in in pooling? On one division of the road that I am connected with we have, outside of our extra men, fifty-two crews in the regular pool. These are operating thirty-seven engines, showing a saving of fifteen engines. If we take the fifteen engines at $10,000 apiece, there is a saving in investment of $150,000. If we take that $150,000 at four per cent interest, we have an interest account of $6,000. Now, I would take that $6,000 and hire additional men to keep up what we have lost by taking work away from the enginemen, and I would figure that I could easily afford to spend that money and still save my $150,000 in the capital invested. So, to answer the question directly, how to make the pooling of locomotives a success, I would say, be very particular to carry out your pooling methods as nearly similar to the conditions that exist when you have a crew assigned to each engine. That is the best way to make pooling a success. (Applause.)

THE PRESIDENT: Gentlemen, we have with us this morning Mr. D. R. McBain, an officer of the Traveling Engineers' Association. Mr. McBain has had considerable experience in this direction and he has kindly consented to give us the benefit of his experience in that line. Mr. McBain, will you please come forward and give us the benefit of your experience?

MR. D. R. MCBAIN: Mr. President and Gentlemen,— I do not know that I can add very much to what has been said on the matter of pooling. I might, however, give the experience of the road with which I am connected. We have pooled engines on one division for the last nine years, where we have old-fashioned and small power, although the system that we have pooled under has not been very perfect. We have depended largely on the men who were running and firing the engines for doing the necessary work and the results have shown that the efficiency of the engines has been maintained and the cost of maintenance has not been increased. We have also been able to save power to a large extent by pooling on that particular division. For the last two years we have pooled on the most important divisions of the system with a large class of engines, 19 by 24 chiefly, without any particular organization or system of round-house repairs other than that all parties understood that they went into the thing at the outset with the intention of doing their part, and the Division Master Mechanic saw to it that everything that was reported of an important nature on the engines was done, and in that way they have kept the enginemen feeling good. The enginemen have seen that the management was willing to keep the engines in fair condition for them and the result has been that instead of the men losing all interest we find that they report things promptly and intelligently, and all the difficulty we have had from the pooling of engines with our very limited organization has been very small. I think that when the business of the company admits it that a locomotive should be handled about the same as a passenger coach. I have heard that expression before: it is not original with me. I think it illustrates the point better than anything else; that the engine should be put in shape to go out and make her trip by round-house organization. I think it is the only way in which power can be utilized when business is rushing and the number of men is limited.

In my observation during ten years' service as a road foreman of engines on a trunk line, if I were asked the question what are the four greatest leaks in locomotive operation I would say, first, uneven distribution of steam in the cylinders; second, any slight defects in front end arrangement; that is, not in any particular arrangement, but all arrangements. If all arrangements in the front ends such as are now used were kept in the best possible condition, or as near as they could be, that would head off the second largest leak I know of. The next thing would be indifferent or unskillful engineers, but particularly indifferent ones, and the last thing, the indifference usually found among firemen.

I wish to thank you, Mr. President, on behalf of the traveling Engineers' Association, as well as for myself, for giving me this opportunity to express my views. I would also like, on behalf of our organization, to extend a cordial invitation to the Master Mechanics' to join the Traveling Engineers' Association. We feel that we would be greatly benefited by your membership and presence among us.

MR. HENDERSON: Mr. President, in addition to the point which was made by Mr. Rhodes in regard to reducing the capital account necessary to maintain the proper number of locomotives for the service, there is another point that it always seemed to me is quite an important one, but I have never heard it mentioned. Let us assume that a locomotive under the old method of running — by that I mean a locomotive for each man, and the locomotive possibly to run one day and lie over the next, the same as the enginemen — let us assume that the locomotive will stand that service for twenty years. Now if a road needs one hundred locomotives to conduct its operations, it will be necessary to provide one hundred locomotives, and we will say that these will last twenty years. If we adopt the method of pooling or double-crewing so that we get twice the mileage out of the engines, it will only be necessary to supply fifty locomotives; of course that means half the capital invested at the time; we save the rest of our money and hold it for ten years. At the end of ten years, the locomotives have made the same mileage as under previous conditions they would have made in twenty years, and it would be necessary to buy fifty more locomotives. But what is the condition? At the end of ten years the design of locomotives has changed, the conditions have changed, and instead of running from the tenth to the twentieth year with a whole lot of locomotives which are partly worn out or are very antiquated in design we get a lot of brand-new locomotives which are up to date, have all the latest improvements upon them and give us very much better results on the strength of the additional information which we gained in those ten years of operation. I think that is a point that is probably fully as important as the question of reducing the capital; that instead of keeping a whole lot of locomotives embodying antiquated construction and ideas, in the course of every ten or twelve years we get new locomotives, up to date, and very much more efficient machines.

There is one of our divisions on which we did a good deal of work in pooling and recently it was decided that some of the work could be done better by double-crewing the engines, and as our Master Mechanic at Clinton, Mr. Bentley, is here, I think possibly he might be able to make some interesting points in regard to what led to the change on that division from pooling to double-crewing on certain freight runs.

Mr. Bentley: Mr. President and gentlemen, I am taken a little by surprise. I did not come prepared to give any information in regard to the pooling or double-crewing arrangement. But on the Iowa Division of the Chicago & North-Western all our freight engines are pooled with the exception of the time freight runs. We found that we got better results by taking the time freight engines and holding them for their regular run, and that the mileage we obtained from those engines on those regular runs was greater than we were obtaining in the pool. We have on each of these time freight runs two engines and three men, and each man will make 202 miles a day and each crew will work one-third of the month, so that instead of having three engines with three crews on the time freights we have two engines and three crews, which is rather better than pooling the engine, for this reason: We have two men whom we hold responsible and who claim the engine as their own. The third man acts as a swing man, alternately taking one engine and then the other on the run and is held accountable for keeping it in condition, just the same as the regularly assigned man. We have in passenger service some of our locomotives that are not pooled, but in some cases we have three men on one engine. One engine I have in mind makes 404 miles every day in the month with the three crews and we get very good results from handling it in that way. The engine leaves Clinton at 12:45 in the morning, gets to Boone about 4:45, lies over there four or five hours and gets back to Clinton at 5 o'clock. From 5 o'clock to midnight is the only time we have to wash it and do repairs and get it in shape for going out again. That engine made 404 miles every day in the month except when it is being held in for necessary repairs that cannot be done in the night time. We find by having three crews on there that they all take more interest in the engine than they would do if nobody owned it or if all the passenger engines were pooled. In the rounds or extra gang we have all our crews pooled, and while I think that the engineers do not take as much interest in their engines as they did when they ran them separately, yet by having some good live road foremen of engines who keep after them and insist that any work that is necessary to be done should be reported we get fairly good results. We also aim to have the work carefully done, so that if any trouble does come up on the road we find that it is not the fault generally of the roundhouse men.

MR. MILLER: Mr. President, we manage our locomotive power something on the method that Mr. Rhodes speaks of in connection with the livery-stable business. We assign regular men to our passenger engines and double-crew them where the runs will admit of it, getting double service out of the locomotives on such runs. On our through freight business we assign regular crews to the locomotives. Our traffic varies, and in winter we have about twice as much business as we can comfortably do, while in summer we have an average. We keep regularly assigned crews on our freight engines. The engines make from forty-five to fifty days a month, while we do not allow the crews to exceed thirty days a month. We have enough extra men to make up the difference between the thirty days for the regular crews and the forty-five or fifty days for the engines. The regular crew will probably make one or two runs, then lie off for a round trip, and an extra crew will be called regardless of what that run is, and they make one round trip and the regular crew is ready to go back. In that way we hold the regularly appointed enginemen responsible largely for the keeping up of the engine and the reporting of the necessary work on the engines to which they are assigned. It gives us the benefit of a regularly assigned crew to the engine, and at the same time, by using the extra crews we keep the engines constantly in service. I took ten of our locomotives for the month of February in rotation, according to the numbers, and found that our average time at terminals, including the washing of boilers and the making of all repairs for these ten engines, was five hours and one minute between the time they arrived at the terminal and their return to service. We have tried assigning three crews to two engines; we have tried the double-crewing, in fact, I think we have tried every method we could think of to make the system work perfectly. There is difficulty in all these methods of handling locomotives and handling men. In our country, where the weather is so severe in the winter there is more or less sickness and you cannot prevent men from getting sick and breaking into any system that you may adopt. We have had three crews run two engines. You cannot prevent engines from breaking down. In the best of machinery there will be breakdowns and troubles coming up that will throw your men out of work. Every engine crew expects to make about so many days per month. It is understood that they will be allowed to make so many days per month. If we assign three crews on two engines, or double-crew the engines, the engine may break down and the men will not get in the time they expected, or, on the other hand, one or two of your men get sick and other men have to replace them. Taking it all through we get the best results and our power is fully as well looked after by having the men assigned regularly, and using the extra men when the traffic is very heavy.

MR. WEST: It has never seemed to me fair on the part of the advocates of pooling locomotives that they should present this enormous saving as against the old method of running engine for engine. I think there are very few roads now assigning an engine to a man. There are other means of meeting these conditions. I have been on roads where engines have been pooled and on roads where engines are regularly assigned and I think that the pooling of engines is a bad practice. On the line with which I am connected we have all regular time-card trains, both passenger and freight, advertised, and the oldest men in seniority bid for the train and two engineers and two firemen are assigned to each engine. We aim to put the best engines on the regular time-card trains, and the few remaining engines or crews that are required to run the extra trains are the engines that are pooled. Consequently we have on all divisions a very small number of pooled engines and both engineers and firemen are making good time and having a good engine, and the older men, both engineers and firemen, are getting the best engines on the road, are making good time and a satisfactory amount of wages and have overcome the bad effects of the pooling system.

In a trip I took from my home in New York to Louisville, a few days ago, at one of the principal stations where engines were changed on passenger trains, I stepped forward to look at the engine, which was a new type, and directly opposite it was a freight train with a new 100-ton engine attached, that evidently had not been out of the shop ten days. The engineer of the freight engine went to the engineer of the passenger train and said: "What do you think? There is a wedge down here and I have got to start out on a 200-mile run." That engine would probably have damaged itself more in running 150 miles with that wedge down than it would in a thousand miles if it had been properly cared for, and I think the same thing is true on all roads where engines are pooled.

MR. DAVID BROWN: I rather admired what Mr. Rhodes said describing the livery stable, but he did not wind up in the manner I expected. I thought he would say that he killed all his horses. I do not fall in with the idea expressed by Mr. Henderson in his remarks about keeping one engine for one man. That is obsolete. But I do believe in double-crewing. I do not believe in pooling. We have passenger engines running 290 miles a day. One crew runs 290 miles and lays off the next day. The other crew takes it and does the same work; that is enough mileage out of the engine for a day's work. We have other trains making 240 miles in the same way, passenger trains. We have coal trains and freight that we used to get 202 miles out of each day by double-crewing and when business was brisk we could do better than that. In place of a crew making three trips a week we would get four out of them by changing them over from one run to another, so that we thought that was doing very well. But now we are pooling them and it is the old story over again. The engineer and fireman do not take the interest in the engine. They jump on an engine and run one way and get off at the other end. Another crew takes the engine and brings it home. When that crew gets back on the trip the engineer ought to make his report; he does to some extent, but not in the manner that he did when they were running double crews. The consequence is we have to get more inspection by roundhouse men, we have to get more work done in the way of firemen's work and more work done in the way of engineers' work, and we do not get any more mileage. So what do we gain by pooling in that way? I say by double-crewing you can get all the mileage out of an engine that you wish to get and do away with the objectionable feature of pooling.

MR. DELANO: Mr. Chairman, I move that this discussion be closed, and in support of that motion I want to point out that the "wild and wooly men" from the West do not expect to come East and convert our "web-footed friends" into our way of looking at things at all. I think that everybody has got to run his livery stable just the way he wants to, just the way he thinks best. He owns the livery stable; if he has got plenty of horses and does not want to wear them out, why he had better take good care of them, just as Mr. Rhodes has indicated.

MR. HENDERSON: I second the motion.

The motion was carried.

THE PRESIDENT: The next question is "Graphite as a Locomotive Lubricant," to be opened by Mr. Henderson.

MR. HENDERSON: Mr. President, we have got comparatively little time left in which to finish up our business so I will make my remarks as brief as possible. The question, as I understand it, is in connection with the lubrication of journals, not of cylinders. We have had some little experience with graphite in the way of lubricating locomotive journals, but I cannot say that it has been very much of a success. When we started out with it we hoped to gain very good results and to be able to reduce the number of hot pins and hot journals. We have tried several methods of using this and it is possible that others have had more success by trying it in a different manner. Our first method was to take the Dixon flake graphite and sprinkle it on the waste in the packing. That was not very satisfactory; the journal would wipe off some of the graphite, but in a short time it would wipe it all off the surface and then a crust formed upon the waste. We next tried by mixing graphite with oil. About ten to fifteen per cent graphite was used in proportion to the oil. This was thoroughly mixed and the waste mixed with it to make a sort of oil and graphite dope, and this was put in the box. Instructions were then given that at regular periods the waste should be turned over enough so as to bring a fresh surface up to the journal and get the benefit of the graphite in this way. That was but partly satisfactory. We also tried the method of mixing the graphite with the oil and introducing it on the journal; but of course it is necessary to have waste on top of the driving box to keep out the sand and dirt, and this waste acts as a filter and filters off the graphite and allows the oil to go through so that you do not get any graphite on the journal. We have also tried the method of using plug graphite and have drilled two or three small holes in the brasses and inserted a little plug of graphite about an inch in diameter and possibly half an inch long, the idea being as the brass wore, that this graphite would also wear down and thoroughly lubricate the journal, but I cannot say that we have had any very marked success with that. For a time I thought that it was going to give rather good results and I felt rather encouraged, but a little later on it did not seem that we had any better results than with regular lubrication. Graphite, we know, is naturally a lubricant and has produced very good results in cylinders, and I believe that if the graphite could be introduced to the journal or bearing that we would get good results, but the great difficulty is to get it on to the bearing in the proper manner to provide lubrication. I was in hopes by these hints I have thrown out we might be able to elicit an expression from our friends who have used it, and find out if a more satisfactory method of introducing it is known. I took up the question with the Dixon Company. I gave them prints of all our oil cups and asked them to make suggestions in some way that would enable us to introduce the graphite successfully with the oil, but after giving the matter quite a study they did not seem to be able to make any very good recommendations. I thought, as they were anxious to introduce the graphite, that I should lay the burden on them to show how to do it. We have tried it in the powdered form, mixed up with oil, and in the stick form, but nothing is very satisfactory. I believe if we get it on the journal it will be a good thing, but we do not know yet how to get it on and the manufacturers do not know how to tell us. It may be that some here have had experience, and if they have I for one would be very thankful to know of it.

MR. BROWN: I think the worst difficulty would be how to get the graphite off the waste in the cellar. It would glaze over the waste and would not be a lubricant.

MR. GIBBS: I think Mr. Brown has hit the difficulty. If you try to lubricate with graphite and oil you must rely upon either one or the other and not the combined efficiency. It acts very much like a hot-box cooler in respect to clogging up the waste by the graphite, which prevents the oil from getting to the journal and unless there is some continuous means of feeding the graphite to the journal the result is that neither lubricant gets where it is wanted.

MR. BROWN: Mr. Gibbs does not understand what I have reference to. I had reference to the waste in the cellar.

MR. GIBBS: That is what I mean.

MR. GILLIS: I think we all know that in some of the Eastern mills graphite is used as a bearing without any lubricant of any kind. It has occurred to me, since Mr. Henderson spoke, that it might be possible to devise a means of using it in that way, only placing it upside down, having your brass on top and the graphite pressed underneath, held up in the cellar against the journal. This would not prevent, of course, any oil that came down from the top of the box, but it would necessarily do away entirely with all lubrication from the cellar. I do not know whether I would like to start that out on a fast train or not, but I might try it on a switching engine or a slow freight. Mr. Henderson just informs me that he is about to try that experiment.

MR. HENDERSON: I mean on your suggestion. I do not wish to steal Mr. Gillis' thunder. I mean that he gave me the tip and I think I will try it.

MR. RHODES: I heard of a method of using graphite recently, not on journal boxes, but it is a way of using graphite and such a useful one that I believe the Association will bear with me if I tell them about it, although I know I am a little out of order. I dare say a great many of us have had trouble occasionally at our homes through the door latches getting a little stiff and not locking. In cars on railroads we will find the latch on the door will frequently stick and the latch will not go up, the same way with windows. There are very few of us who travel that do not have to travel with graphite; that is to say we all carry our lead-pencils, and if any of you gentlemen have any difficulty with those latches either at your homes or on your windows or on the doors of coaches, a quick remedy is to take your pencil and to rub it over the latch and around the latch and you will be surprised at the charm with which it will work. I have practiced it in my own home. Our chief car inspector, William Baird, told me of this idea not very long ago, and it has been so useful that I have not missed an opportunity of mentioning it whenever I got a chance.

On motion of Mr. Gibbs the discussion was closed.

MR. DELANO: Mr. Chairman, I find I am last on the list for topical discussion, and I would suggest that a good many of the members here would rather hear the report on subjects and dispose of the other business of the meeting. If there is any time left after that and there are still any members left to hear from Subject No. 7, I shall be very glad to speak then. I would therefore suggest that Subject No. 7 be omitted now and that we proceed to the regular business of the meeting.

THE PRESIDENT: Unless there are objections made to the suggestion of Mr. Delano we will now proceed with the next order of business which will be the report on Subjects.

The Committee on Subjects presented the following report:

REPORT OF COMMITTEE ON SUBJECTS.

To the President and Members of the
American Railway Master Mechanics' Association:

Your committee appointed to propose subjects to be investigated during the coming year, and reported upon at the convention in June, 1901; also to propose subjects for topical discussion at this convention, respectfully proposes the following:

FOR COMMITTEE WORK DURING THE COMING YEAR.

1. What is the most economical speed for freight trains?

2. Different types of locomotive fire-boxes now in use, and most promising type for passenger, freight and switch engines?

3. What is the cost of running high-speed passenger trains?

4. The most satisfactory method of handling, cleaning and setting boiler tubes?

5. What is the most promising direction in which to effect a reduction in locomotive coal consumption?

6. What should be the arrangement and accessories of an up-to-date roundhouse?

7. Maximum monthly mileage that is practicable and advisable to make; how best to make it, both in passenger and freight service?

8. What is the most approved method for unloading locomotive coal, prior to being unloaded on the tank?

FOR TOPICAL DISCUSSION DURING THIS CONVENTION.

1. The best method for securing eccentric straps to the rods.
To be opened by C. H. Quereau.

2. Nickel steel as a journal bearing. Is there any noticeable increase in friction or wear, as compared with the ordinary steel or iron?
To be opened by W. H. Lewis.

3. Has the limit of length of tubes 2 inches in diameter been reached in locomotive practice?
To be opened by S. M. Vauclain.

4. Metal vs. wooden cabs for locomotives.
To be opened by J. E. Sague.

5. Strap vs. jaw, back end of main rod.
To be opened by S. P. Bush.

6. Graphite as a locomotive lubricant.
To be opened by G. R. Henderson.

7. Advantages of increasing ratio of grate area to heating surface in locomotives burning bituminous coal.

To be opened by F. A. Delano.

8. How to make pooling of locomotives a success?

To be opened by G. W. Rhodes.

R. QUAYLE, Chairman,
G. W. RHODES,
F. D. CASANAVE,
Committee.

CHICAGO, ILL., May 18, 1900.

On motion of Mr. Delano the report was received and accepted.

THE PRESIDENT: I presume, Mr. Delano, that it was your intention to refer it to the Executive Committee.

MR. DELANO: It was.

THE PRESIDENT: Next order of business will be the report of the Committee on Resolutions and Correspondence — Mr. Whyte.

MR. WHYTE read the following report:

To the American Railway Master Mechanics' Association:

GENTLEMEN,—Your committee appointed to prepare for your consideration resolutions suitably expressing your appreciation of the kindness of those who have contributed to making the convention a success, beg to submit the following:

Resolved, That the sincere thanks of this Association are due and are hereby tendered to the Rev. Delos Jump for his kindness in opening the convention with prayer; to Mr. A. J. Pitkin, for the well-chosen words of welcome; to the Michigan Central, Delaware & Hudson, Fitchburg, Boston & Albany and New York Central & Hudson River Railroads and the Pullman Company for transportation favors extended by them; to the Supply Men's Association for the very liberal entertainment provided; to the Committee on Arrangements for the perfect plans made for our meeting; to the *Daily Railway Age* for its diligence in presenting each morning an account of the happenings of the day and night preceding, as well as for the day at hand; to the managers of the Grand Union Hotel, Mr. W. E. Woolley and Mr. H. M. Gerrans, for their courteous and considerate treatment of the members and their friends; to the Schenectady Locomotive Works for the invitation extended to visit the works at Schenectady and the very enjoyable reception that was accorded on the part of the locomotive works, and to the Lehigh Valley Railroad for the facilities placed at the disposal of the Committee on Flanged Tires.

F. M. WHYTE.
G. R. HENDERSON.
C. J. MELLON.

MR. DELANO: I move the adoption of the report.

The motion was carried.

THE PRESIDENT: The next order of business is the election of officers for the ensuing year. I will appoint as tellers to collect the ballots Mr. Whyte and Mr. Peck. Gentlemen, please prepare your ballots for the election of President.

MR. HENDERSON: Before the vote is taken I would call atttention to the fact that I have been called Mr. Morris several times during the convention and I hope the members will still keep that in mind.

MR. MORRIS: I appreciate the compliment.

THE PRESIDENT: Have all the gentlemen voted? If so the ballot is closed. While the ballot is being counted I would suggest that you prepare your ballots for First Vice-President.

MR. DELANO: I do not know what the Constitution provides, but I should think that if it is not prohibited in the Constitution and By-Laws we might vote for First, Second and Third Vice-Presidents on one ballot, taking the three highest — those having the three highest number of votes, in that order.

THE PRESIDENT: As it was suggested here a few days ago that the Executive Committee was not posted on the Constitution, it will be necessary to look that matter up before giving an answer to your question.

THE SECRETARY: In regard to the election of officers Section 1 of Article VIII says:

> The officers of the Association, except the secretary, as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed.

THE PRESIDENT: It would seem that it would be better, Mr. Delano, to follow out the usual practice and elect each one by ballot.

MR. PECK: The total number of votes cast is 37. Mr. Morris receives 34; Mr. Waitt 3. I make the motion that the Secretary cast the ballot for Mr. Morris for President of the Association.

MR. WAITT: I move that the vote be made unanimous for Mr. Morris.

MR. PECK: I accept that.

The motion was carried.

Mr. McConnell: Gentlemen, you have made a very wise selection for President of this Association. In retiring from the office permit me to thank you for the kind and considerate manner in which you have treated the late President, who is now about to become a back number on all occasions. I desire further to say that it has been the universal opinion of the members present that this has been one of the best conventions that has ever been held. The subjects have all been of an interesting and entertaining character and it seems to me we have derived more general information from the discussions this time than from those at any other convention which I have ever attended. Gentlemen, in retiring, I desire to tender to you my sincere thanks for your kindness. I have the pleasure of presenting to you the newly elected President of this Association. (Applause.)

President Morris: Mr. Chairman and Gentlemen of the Association,— I thank you for the great honor which you have conferred upon me by electing me as your President. I am not accustomed to presiding over such large bodies as this and I must ask, and I feel that I shall receive, your indulgence and assistance for the benefit of the Association. It has been my aim to win your esteem, not your votes. I congratulate myself that I have received a reasonable share of both, and I shall endeavor to serve you all to the best of my ability so long as I shall occupy the position to which you have elected me. I wish to say to the retiring President that I thank him personally for the many things that he has done while in office for me and for the Executive Committee, and while some criticism has been made about the Executive Committee's knowledge of the Constitution, I think that the present Executive Committee, not barring the ex-President, are fully conversant with the old Constitution and hope to see the new, which will be a better Constitution, in operation next year. I thank you again, gentlemen. (Applause.)

Mr. McConnell: In consideration of your kind remarks, Mr. President, I have the pleasure of presenting you with the gavel of the Association.

Mr. Whyte: I move that the thanks of the Association be tendered to the past President for the very able manner in which he has conducted the affairs of the Association and of the convention. (Seconded.)

The motion was carried.

THE PRESIDENT: We will now proceed to the election of a First Vice-President. The tellers will please collect the ballots. Have all voted who wish to? I now declare the ballot closed for First Vice-President. While the tellers are counting the ballots, please prepare your ballots for Second Vice-President.

MR. PECK: Mr. President, 38 votes were cast for First Vice-President, of which Mr. Waitt receives 36 and Mr. Barr 2.

MR. DELANO: I move that the election of Mr. Waitt be made unanimous.

The motion was carried.

MR. WAITT: Members of the Convention,— I wish to heartily thank you for the honor you have conferred upon me and to say that I will do all that I can during the coming year to assist the President in his duties and to forward the interests of the Association. (Applause.)

THE PRESIDENT: The tellers will now collect the ballots for Second Vice-President. Have all voted who wish to for Second Vice-President? If so, I now declare the ballot closed. You will please prepare your ballots for Third Vice-President while the tellers are counting the ballots for Second Vice-President.

MR. PECK: Mr. President, the number of votes cast for Second Vice-President was 38, of which Mr. Barr receives 30 and Mr. Delano 8.

MR. WAITT: I move that the vote for Mr. Barr be made unanimous. (Seconded.)

The motion was carried.

THE PRESIDENT: The tellers will now proceed to collect the ballots for Third Vice-President. If all the gentlemen have voted I will now declare the ballots closed for Third Vice-President. You may prepare your ballots for Treasurer.

MR. PECK: Mr. President, 40 votes were cast for Third Vice-President. Mr. West received 24; Mr. Delano 13; 3 scattering.

Mr. West having a majority I make the motion that his election be declared unanimous. (Seconded.)

The motion was carried.

Mr. West: I thank you, gentlemen, for the kind consideration given me in this matter and I assure you that I will do what I can to make the work of the Association the coming year a success. I will sustain the President and the Executive Committee in their efforts on behalf of the Association. (Applause.)

The President: The tellers will please collect the ballots for Treasurer. Have all the members present voted who wish to? If so I declare the ballot for Treasurer closed.

Mr. Peck: Mr. President, the total number of votes cast for Treasurer is 37, of which Mr. Sinclair receives 18; W. H. Marshall, 1; Mr. Gillis, 2; Mr. Rhodes, 6; Mr. Delano, 6; 2 scattering, 1 blank and 1 for Mr. Taylor.

The President: There appears to be no election in this case. Please prepare your ballots again for the office of Treasurer.

Mr. Delano: I believe it to be consistent with the Constitution to pass a motion that the Secretary be instructed to cast the ballot of the Association for Mr. Sinclair, he having received a large majority of the votes.

The President: Gentlemen, you have heard the motion, that the Secretary cast the ballot for Mr. Sinclair as Treasurer.

Mr. Gillis: I would like to ask if that is constitutional.

The President: Mr. Gillis, I would rule that it is constitutional. All those in favor of the motion will signify it by saying " aye "; contrary minded " no."

The motion was carried.

The President: It is unanimous. Mr. Sinclair is elected Treasurer. If Mr. Sinclair is in the room I would like to have him come forward.

Mr. McConnell: If there is no further business before this convention I move that we now adjourn.

Mr. West: Before that motion is put I think there are a good many members here who would like to hear the paper that Mr.

Delano has prepared. The subject was put over until this matter could be disposed of.

MR. DELANO: I believe that the members would rather have that postponed until next year, and perhaps I will know something about the subject next year.

THE PRESIDENT: The motion to adjourn is before you, gentlemen. All those in favor will signify by saying " aye "; contrary, " no."

The motion was carried and the meeting adjourned.

STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

SCREW THREADS.

At the Third Annual Convention the report of a committee recommending the United States standard screw thread was adopted. Annexed are the forms and dimensions of the threads in question.

Fig. 1.

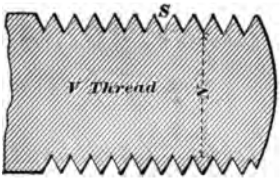


Fig. 3.

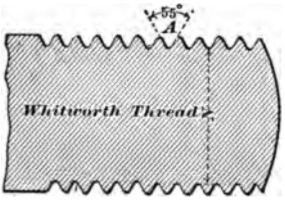
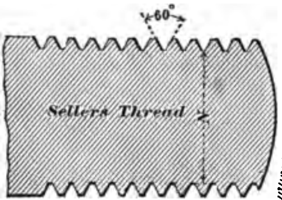


Fig. 5.



SCREW THREADS.

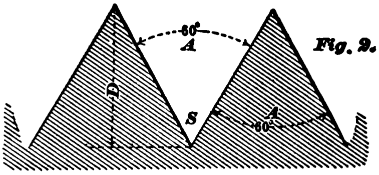


Fig. 2.

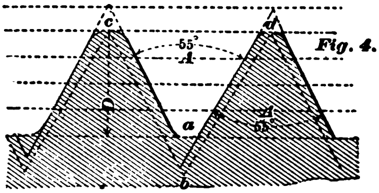


Fig. 4.

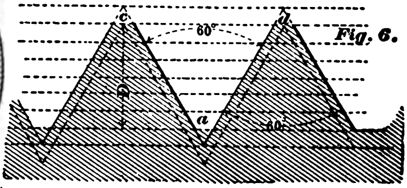
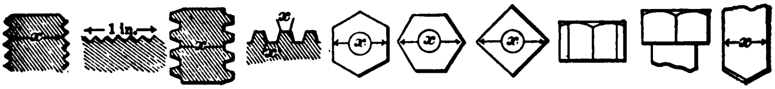


Fig. 6.

SELLERS' STANDARD.

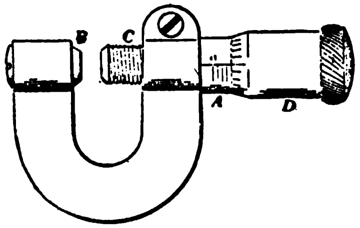
The Association at the Twenty-fifth Annual Convention adopted the United States standard sizes of nuts and bolt heads, particulars of which are given below:



Diameter of Screw.	Threads per inch.	Diameter at Root of Thread.	Width of Flat.	Short Diameter of Hexagon or Square.	Long Diameter Hexagon.	Long Diameter Square.	Thickness Nuts.	Thickness Heads.	Tap Dril.
1/4	20	.185	.0062	1/2	37/64	7/10	1/4	1/4	3/16
5/16	18	.240	.0074	19/32	11/16	10/12	5/16	19/64	1/4
3/8	16	.294	.0078	11/16	51/64	63/64	3/8	11/32	5/16
7/16	14	.344	.0089	25/32	9/10	1 7/64	7/16	25/64	25/64
1/2	13	.400	.0096	7/8	1	1 15/64	1/2	7/16	13/32
9/16	12	.454	.0104	31/32	1 1/8	1 23/64	9/16	31/64	15/32
5/8	11	.507	.0113	1 1/16	1 7/32	1 1/2	5/8	17/32	17/32
3/4	10	.620	.0125	1 1/4	1 7/16	1 49/64	3/4	5/8	5/8
7/8	9	.731	.0138	1 7/16	1 21/32	2 1/32	7/8	23/32	3/4
1	8	.837	.0156	1 5/8	1 7/8	2 19/64	1	13/16	27/32
1 1/8	7	.940	.0178	1 13/16	2 3/32	2 9/16	1 1/8	29/32	31/32
1 1/4	7	1.065	.0178	2	2 5/16	2 53/64	1 1/4	1	1 3/32
1 3/8	6	1.160	.0208	2 3/16	2 17/32	3 3/32	1 3/8	1 3/32	1 3/16
1 1/2	6	1.284	.0208	2 3/8	2 3/4	3 23/64	1 1/2	1 3/16	1 9/32
1 5/8	5 1/2	1.389	.0227	2 9/16	2 31/32	3 5/8	1 5/8	1 9/32	1 13/32
1 3/4	5	1.491	.0250	2 3/4	3 3/16	3 57/64	1 3/4	1 3/8	1 1/2
1 7/8	5	1.616	.0250	2 15/16	3 13/32	4 5/32	1 7/8	1 15/32	1 5/8
2	4 1/2	1.712	.0277	3 1/8	3 5/8	4 27/64	2	1 9/16	1 3/4
2 1/4	4 1/2	1.962	.0277	3 1/2	4 1/16	4 61/64	2 1/4	1 3/4	1 31/32
2 1/2	4	2.176	.0312	3 7/8	4 1/2	5 31/64	2 1/2	1 15/16	2 3/16
2 3/4	4	2.426	.0312	4 1/4	4 29/32	6	2 3/4	2 1/8	2 7/16
3	3 1/2	2.629	.0357	4 5/8	5 3/8	6 17/32	3	2 5/16	2 5/8
3 1/4	3 1/2	2.879	.0357	5	5 13/16	7 1/16	3 1/4	2 1/2	2 29/32
3 1/2	3 1/4	3.100	.0384	5 3/8	6 7/64	7 39/64	3 1/2	2 11/16	3 1/32
3 3/4	3	3.317	.0413	5 3/4	6 21/32	8 1/8	3 3/4	2 7/8	3 11/32
4	3	3.567	.0413	6 1/8	7 3/32	8 41/64	4	3 1/16	3 19/32
4 1/4	2 7/8	3.798	.0435	6 1/2	7 9/16	9 3/16	4 1/4	3 1/4	3 13/16
4 1/2	2 3/4	4.028	.0454	6 7/8	7 31/32	9 3/4	4 1/2	3 7/16	4 1/32
4 3/4	2 5/8	4.256	.0476	7 1/4	8 13/32	10 1/4	4 3/4	3 5/8	4 9/32
5	2 1/2	4.480	.0500	7 5/8	8 27/32	10 49/64	5	3 13/16	4 1/2
5 1/4	2 1/2	4.730	.0500	8	9 9/32	11 23/64	5 1/4	4	4 3/4
5 1/2	2 3/8	4.953	.0526	8 3/8	9 23/32	11 7/8	5 1/2	4 3/16	4 31/32
5 3/4	2 3/8	5.203	.0526	8 3/4	10 5/32	12 3/8	5 3/4	4 3/8	5 7/32
6	2 1/4	5.423	.0555	9 1/8	10 19/32	12 15/16	6	4 9/16	5 7/16

SHEET METAL GAUGE.

At the Fifteenth Annual Convention the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal.



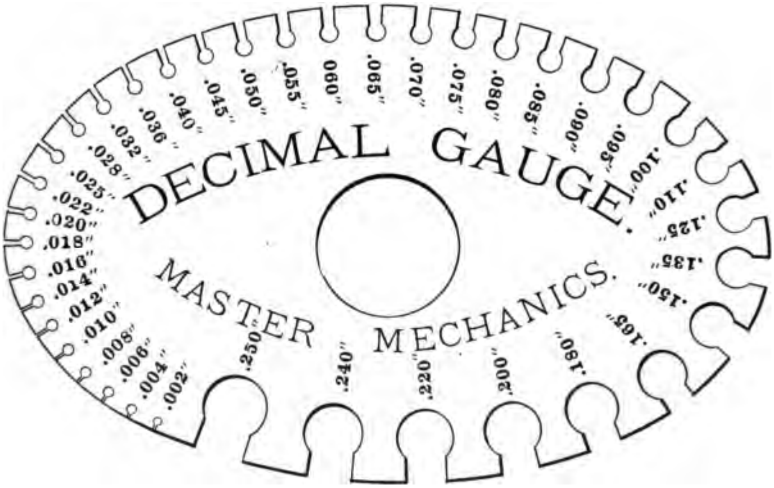
DECIMAL GAUGE.

At the Twenty-eighth Annual Convention the following was adopted as standard decimal gauge:

1st. The micrometer caliper should be used for laboratory and toolroom work, and in the shop when specially desired.

2d. The solid notch gauge should be used for general shop purposes.

3d. The form of this gauge shall be an ellipse whose major axis is 4 inches, the minor axis 2.5 inches, and the thickness .1 inch, with a central hole .75 inch in diameter.



4th. The notches in this gauge shall be as follows:

.002″
.004″
.006″
.008″
.010″
.012″
.014″
.016″
.018″
.020″
.022″
.025″
.028″
.032″
.036″
.040″
.045″
.050″
.055″
.....
.060″
.065″
.070″
.075″
.080″
.085″
.090″
.095″
.100″
.....
.110″
.125″
.135″
.150″
.165″
.180″
.200″
.220″
.240″
.250″

5th. All notches to be marked as in the above list.

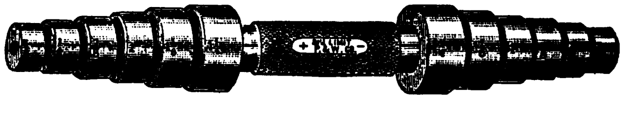
6th. The gauge must be plainly stamped with the words "Decimal Gauge" in capital letters .2 inch high, and below this the words "Master Mechanics."

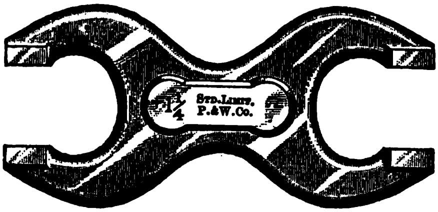
7th. In ordering material, the term gauge shall *not* be used, but the thickness ordered by writing the decimal as in above list. For sizes over ¼ inch, the ordinary common fractions may be used.

LIMIT GAUGES.

At the Seventeenth Annual Convention the Pratt & Whitney limit gauges for round iron, illustrated on this and following page, were adopted. The sizes are as follows:

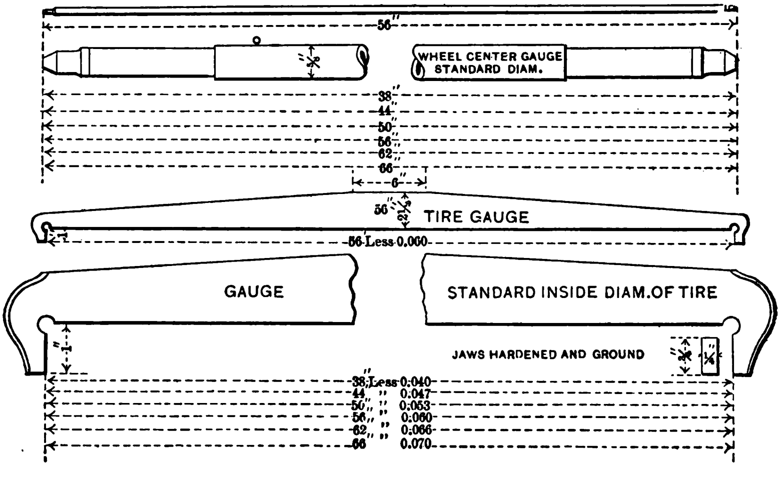
NOMINAL DIAMETER. OF IRON. INCHES.	**Large Size, End. Inches.**	**Small Size, End. Inches.**	**Total Variation. Inches.**
¼	.2550	.2450	**.010**
5/16	.3180	.3070	**.011**
⅜	.3810	.3690	**.012**
7/16	.4440	.4310	**.013**
½	.5070	.4930	**.014**
9/16	.5700	.5550	**.015**
⅝	.6330	.6170	**.016**
¾	.7585	.7415	**.017**
⅞	.8840	.8660	**.018**
1	1.0095	.9905	**.019**
1 ⅛	1.1350	1.1150	**.020**
1 ¼	1.2605	1.2395	**.021**





DRIVING-WHEEL CENTERS AND SIZES OF TIRES.

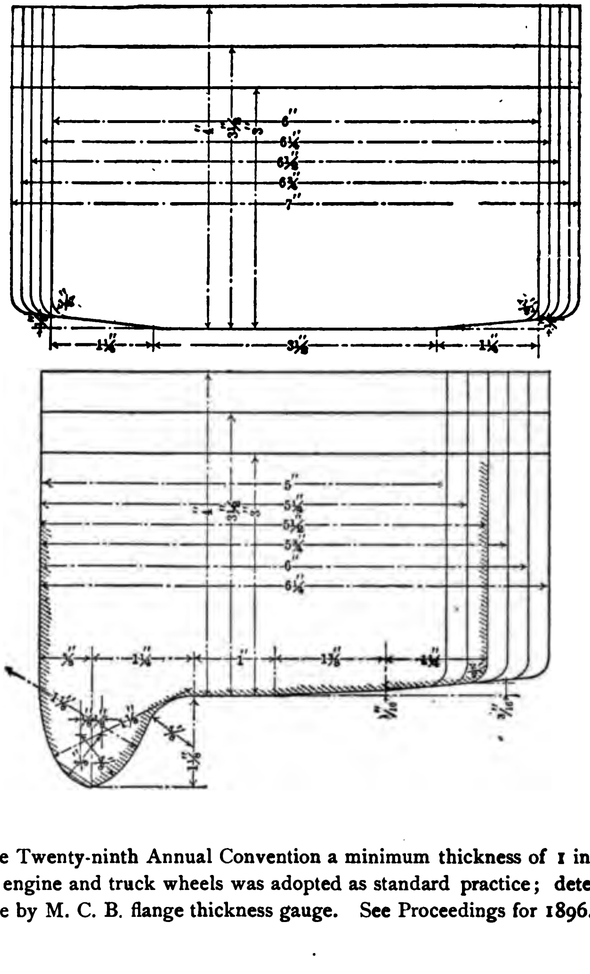
At the Nineteenth Annual Convention the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, and here illustrated, standards of the Association. The sizes and the allowance for shrinkage are as follows:



At the Twenty-sixth Annual Convention the following sizes were adopted as standard for large driving wheels: 70, 74, 78, 82, 86 and 90 inches.

STANDARD FORMS OF TIRES.

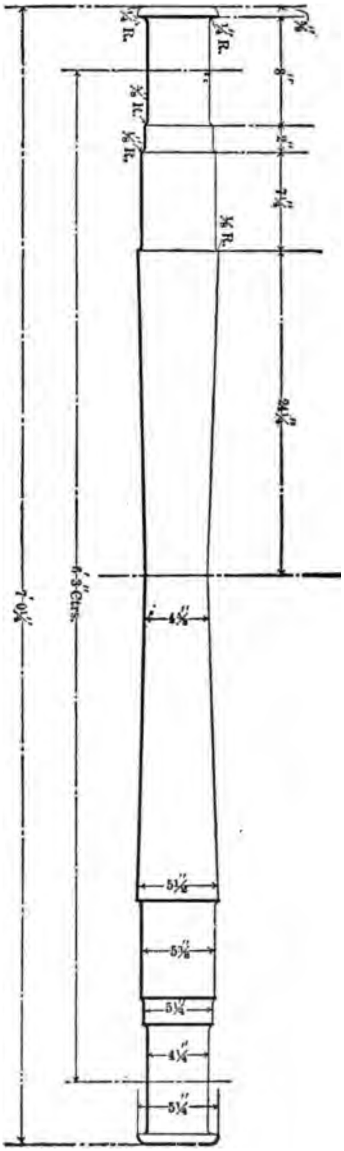
At the Twenty-sixth Annual Convention the forms of tires shown in the annexed engraving were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.



At the Twenty-ninth Annual Convention a minimum thickness of 1 inch for the flanges of engine and truck wheels was adopted as standard practice; determination to be made by M. C. B. flange thickness gauge. See Proceedings for 1896.

AXLE FOR HEAVY TENDERS.

The accompanying illustration shows the dimensions of the axles for heavy tenders recommended by a committee of the Association.



METHOD OF CONDUCTING LOCOMOTIVE TESTS.

Adopted at the Twenty-seventh Annual Convention; full details, page 166, Twenty-seventh Annual Report.

BOILER STEEL SPECIFICATIONS.

Adopted at Twenty-seventh Annual Convention; full details, page 68, Twenty-seventh Annual Report.

SPECIFICATIONS AND TESTS FOR LOCOMOTIVE IRON BOILER TUBES, EXTRA QUALITY.

Adopted at Twenty-eighth Annual Convention.

Material.

Tubes to be made of knobbled hammered charcoal iron and lap-welded.

Dimensions and Weights.

Tubes 2 inches, outside diameter.

.095 inch thick and weight at least 1.91 lbs. per foot.
.110 " " " " 2.19 " "
.125 " " " " 2.47 " "
.135 " " " " 2.65 " "

Tubes 2¼ inches, outside diameter.

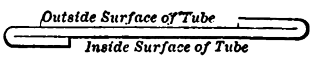
.095 inch thick and weight at least 2.16 lbs. per foot.
.110 " " " " 2.48 " "
.125 " " " " 2.80 " "
.135 " " " " 3.01 " "

Surface Inspection.

Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must also be free from bends, kinks and buckles — signs of unequal contraction in cooling or injury in manipulation — and must be of uniform thickness throughout, except at weld, where .015 inch additional will be allowed, perfectly round and cut to exact length ordered.

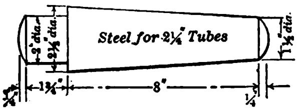
Physical Tests.

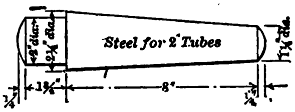
1. Strips one-half inch in width by six inches in length, planed lengthwise from tubes, after being heated to a cherry red and dipped in water at 80 degrees Fahrenheit, shall bend in opposite directions at each end as shown in sketch below, without showing cracks or flaws; and when nicked and broken these must show a fracture wholly fibrous, or a test in a testing machine may be substituted for this.



2. Sections of tubes 12 inches long — five inches of which shall be heated to a *bright cherry red* in daylight — when placed in a vertical position, and a smooth-turned tapered steel pin at a *blue heat* is driven in, by "lap" blows with a 10-pound sledge hammer, must stretch to one and one-eighth times their original diameter without split or crack. One tube to be tested, as required in paragraphs 1 and 2, in each lot of 250 tubes or less.

The sketches below show dimensions of steel pins to be used for 2-inch and 2¼-inch O. D. tubes.





3. Tubes must expand, turn over tube plate and bend down without flaw, crack or opening at weld.

Hydraulic Test.

Each tube must be subjected, by the manufacturer, to an internal pressure of 500 pounds to the square inch.

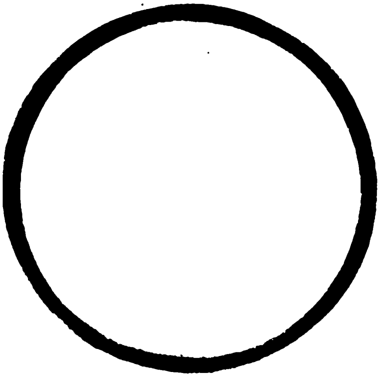
Etching Tests.

In case of doubt as to the quality of material, the following tests shall be used namely:

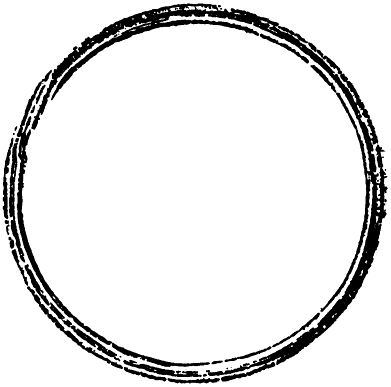
A section of tube turned or ground to a perfectly true surface, polished with fine emery paper, and free from dirt and grease, to be suspended in a bath of

Water........................	9 parts.
Sulphuric acid.................	3 "
Muriatic "	1 "

The bath should be prepared by placing the water in a porcelain dish, adding the sulphuric acid and then the muriatic acid. Chemical action is allowed to con-



Steel.



Charcoal Iron.

tinue until the soft parts are sufficiently dissolved so that an iron tube will show a more or less finely ridged surface, with the weld very distinct; a steel tube will present a homogeneous surface.

General Requirements.

Each tube must be plainly stenciled "Knobbled Hammered Charcoal Iron" and "Tested to 500 Pounds," and tubes must be so invoiced. Each tube must also be subjected to careful surface inspection, as provided for above; and those measuring one sixty-fourth of an inch over or under the diameter ordered shall be rejected.

BRIGGS STANDARD WROUGHT-IRON PIPE THREADS.

At the Thirty-Second Annual Convention what is known as the Briggs Standard, as determined by the Pratt & Whitney gauges, of threads for wrought-iron pipe and couplings, was adopted as a standard of the Association.

The gauges used by the Pratt & Whitney Company were made by them from an autograph copy of a table made by Mr. Robert Briggs personally, who originally established and published these standard threads. A copy of it is as follows:

STANDARD DIMENSIONS OF WROUGHT-IRON WELDED TUBES. BRIGGS STANDARD.

Diameter of Tube.			Thickness of metal.	Screwed Ends.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of perfect screw.
Inches.	Inches.	Inches.	Inch.	No.	Inch.
⅛	0.270	0.405	0.068	27	0.19
¼	0.364	0.540	0.088	18	0.29
⅜	0.494	0.675	0.091	18	0.30
½	0.623	0.840	0.109	14	0.39
¾	0.824	1.050	0.113	14	0.40
1	1.048	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.468	2.875	0.204	8	0.89
3	3.067	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.982	8.625	0.322	8	1.46
9	9.000	9.688	0.344	8	1.57
10	10.019	10.750	0.366	8	1.68

Tapers of conical tube ends, 1 in 32 to axis of tube. (¾-inch per foot.)

By the late action of the Manufacturers of Wrought-Iron Pipe, 9-inch outside diameter has been excepted from the original list, as above noted, the diameter now adopted being 9.625 instead of 9.688 inches given in the Briggs table.

In 1899 the [illegible] standard:

The short diam[illegible] bolt, and the thick[illegible]

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Obituary.

JOHN EDWARD BATTYE.

John Edward Battye was born in Huddersford, near Leeds, England, October 19, 1848. He came to the United States May 22, 1862, and served his apprenticeship as machinist with the William Woods Machine Company. In 1870 he entered the service of the Pennsylvania Railroad Company, remaining until 1882, when he entered the service of the Marine Works, in Chicago, Illinois. He returned to Lambertville, New Jersey, in 1883 and entered the service of the Lambertville Iron Works, where he remained until 1885. He then entered the service of the Norfolk & Western Railroad Company, and after three months was appointed Gang Foreman. In 1888 he was appointed Master Mechanic of the Shenandoah Valley Railroad Company and was retained in that position after the road was absorbed by the Norfolk & Western Railroad Company. In 1897 he was appointed General Foreman of the Locomotive Department of the Roanoke Shops of the Norfolk & Western Railway Company, and in February, 1900, was appointed Division Master Mechanic of the Eastern General Division. He died May 17, 1900, and was buried in Fernwood Cemetery, in Philadelphia, Pennsylvania.

Mr. Battye was a man of superior skill and ability as a mechanic, and was possessed of qualities of mind and heart that endeared him to all with whom he was brought in contact. He was a loyal friend, kind husband and indulgent father, and his death was considered a personal loss by all of his associates, whose sincere sympathy was extended to the bereaved wife and family.

W. H. Lewis.

J. B. GLOVER, Jr.

Born at Marietta, Georgia, September 14, 1866. He was educated at the High School, Marietta, and Lehigh University, South Bethlehem, Pennsylvania, September, 1884, class of 1888. He graduated with third honors in a large class, and with first honors in the Mechanical Engineering Department, having distinguished himself in the Engineering Department. He allied himself with the A. T. O. Fraternity.

On his return from the University he entered the employ of the Central of Georgia railroad shops, at Savannah, Georgia, in the Drafting and

Designing Department. He filled the position with credit to himself and to the entire satisfaction of his employers.

In 1890 he entered the employ of the Marietta & North Georgia Railroad, at the shops in Marietta, and in 1891 he was appointed Superintendent of Motive Power. He resigned from same road in December, 1896, after it was changed to the Atlanta, Knoxville & Northern Railroad, on account of his failing health and other business interests. The condition of the rolling stock of the Atlanta, Knoxville & Northern when turned over to his successor was an honor to the highest mechanic.

In 1892 he bought a small plant known as the Phoenix Foundry and Machine Works. At the time his health failed in December, 1896, this small plant had increased five hundred per cent, and had gained a reputation second to none in the South. He died August 16, 1897, from paralysis of the brain and complications brought on by too close application to business.

He was universally liked and respected by all who knew him, and his moral character was simply above reproach. W. E. SYMONS.

WILLIAM HENRY HARRISON.

William Henry Harrison was born at Baltimore, Maryland, July 10, 1832. He served an apprenticeship at the machinist's trade in the shops of the Northern Central Railroad at Bolton Depot shops, Baltimore. He entered the service of the Baltimore & Ohio Railroad as machinist February 22, 1854, at Fetterman, West Virginia; was promoted to foreman at Fetterman shortly afterward, holding that position until September 1, 1858, when he was made Master Mechanic at Wheeling, West Virginia, which position he held until July, 1863, at which time he was transferred to Mount Clare, Baltimore, as Master Mechanic, where he remained until October, 1864, and was then transferred back to Wheeling as Master Mechanic, holding this position until August 15, 1872, when he was promoted to the position of Master of Machinery of the Pittsburg & Connellsville Railroad (Pittsburg Division of Baltimore & Ohio Railroad). On March 1, 1873, he was again promoted and made Assistant Master of Machinery of the Main Stem Division, consisting of all lines East of the Ohio River, with headquarters at Cumberland, Maryland. This position he held until January 1, 1881, when he was again promoted, being made Master of Machinery of the Trans-Ohio Division, with headquarters at Newark, Ohio. January 1, 1886, he was made Superintendent of Motive Power of the entire system, with office at Mount Clare, Baltimore. May 1, 1887, this office being abolished, he was transferred to Newark, Ohio, as Superintendent of Motive Power of the Trans-Ohio Division, which position he held until

May, 1899, when he retired from active service, after a continuous service with the Baltimore & Ohio Railroad of over forty-five years.

His integrity and genial personality impressed itself upon all those with whom he was associated. He died at Newark, Ohio, September 9, 1899, and is held in grateful remembrance by a host of employes who served with and under him. J. N. Barr.

JOHN TORRENCE.

John Torrence was born in Calderbank, Scotland, January 28, 1836. Mr. Torrence learned the trade of machinist with the celebrated ship builder, Robert Napier, near Glasgow, Scotland. His first visit to this country was in 1857, as second engineer on the Government inspection ship Lady Head. He continued in this service for two years. He came to this country and took service with the New York Central Railroad at Buffalo, in 1859. His service with that company was of short duration. Coming to Evansville in 1860 he associated himself with the Evansville & Terre Haute Railroad as machinist. In 1862 he went to Paducah, Kentucky, and entered the service of the Memphis & Ohio Railroad, now part of the Illinois Central System. In 1861 Mr. Torrence again took service with the Evansville & Terre Haute Railroad, remaining with them until the time of his death, April, 1899.

He became a member of the American Railway Master Mechanics' Association in 1885. Mr. Torrence was a man of the highest moral character, being upright and honest in his dealings with his fellow men and highly respected by all who knew him. W. C. Arp.

GEORGE BENJAMIN ROSS.

Born February 27, 1846, of Scotch parents, at Toronto, Ontario, died in the city of Buffalo, New York, April 23, 1899.

Mr. Ross was a man of exceptional ability in the mechanical line, to which his inclination ran from youth. His apprenticeship was served at Buffalo, 1860-1863, in the Buffalo Steam Engine Works. He enlisted in the United States Army, serving faithfully as a soldier until honorably discharged in 1865. He then entered the service of the Erie Railroad Company as machinist, in 1869, at Buffalo, remaining until 1878, when his ability as a mechanical engineer was recognized by both the United States Government and the State of New York. Serving both governments in positions of trust until 1880, he again entered the service of the Erie Railroad Company as Foreman at Susquehanna Machine Shop; promoted to Master Mechanic at Buffalo, 1881, remaining until 1885. Between this date and 1890 Mr. Ross was employed by various firms at Scranton, Pennsylvania, New York City and Buffalo; returning to the Erie Railroad Company as Master Mechanic of the Buffalo Shops, serving with credit and ability until ill health required his relief from active railroad duties in 1892. From this date until his death, April 23, 1899, Mr. Ross retained his interest in all matters pertaining to mechanical appliances, especially as related to railroad service.

Among the devices which have made his name conspicuous as an inventor are the "Ross brake shoe," "Ross loose pulley" and "Ross steam trap," known and used largely throughout the United States. W. LAVERY.

WILLIAM H. STEARNS.

Mr. William H. Stearns was born in Lowell in 1822, and was the son of Oliver Stearns, an influential lawyer in that place. He began at the age of fourteen years to learn the machinist's trade, and at the age of nineteen he went to Springfield, Massachusetts, where he was employed by the Western Railroad, now the Boston & Albany. After working as a machinist a few years, he removed to South Braintree, Massachusetts, and for a number of years was employed as a locomotive engineer by the Old Colony Railroad. Returning to Springfield, he entered the employ of the Boston & Albany Railroad until 1871, when he was appointed Master Mechanic of the Connecticut River Railroad. In local railroad service there was perhaps no better known man than Mr. Stearns. He retired Saturday night, July 13, in apparently good health. He awoke at four o'clock the following morning and before a physician could be summoned he was dead.

Mr. Stearns became a member of the American Railway Master Mechanics' Association in 1872.

J. G. TOMLINSON.

J. G. Tomlinson, who was killed at Meridian, Mississippi, on July 24, 1899, was born in Derby, England, in 1858. He came to this country in 1882 and accepted a position as draftsman for the Cincinnati, New Orleans & Texas Pacific Railway, and later was Assistant Superintendent of Motive

Power of that road for a number of years. He was afterward transferred to Chattanooga, Tennessee, as Master Mechanic of the same road. This position he held until he was transferred to the Birmingham shops of the Alabama Great Southern Railway.

In March, 1892, he took charge of the Meridian shops of the New Orleans & North-Eastern Railroad as Master Mechanic, and in September, 1895, he was promoted to the position of Superintendent of Motive Power of the New Orleans & North-Eastern Railroad, Alabama & Vicksburg Railroad and Vicksburg, Shreveport & Pacific Railroad, which position he held until the time of his death.

His faithfulness, combined with natural ability and familiarity with all branches of railroad service, made him of great assistance to the roads with which he was connected, and this was the principal factor of his success in railroad life. He was devoted to the interests of the companies he served, took an active part in the betterment of all employes under his charge and was respected and esteemed by every one. By his death the railroad with which he was connected lost a valuable official and the employes a good friend.

He became a member of the Master Car Builders' Association in 1895.

C. Lindstrom.

THOMAS CARMODY.

Mr. Thomas Carmody died in Cleveland, April 14, 1900, from injuries received in an accident. He was born March 29, 1861, at Cadiz Junction, Harrison County, Ohio, and was the son of John and Catherine Carmody.

At the age of sixteen he entered the shops of the Pittsburgh, Cincinnati, Chicago & St. Louis Railroad, at Dennison, Ohio, as a machinist apprentice, completing his apprenticeship three years later. Soon afterward he was transferred to the Pittsburg roundhouse of the same company, where he worked as a machinist for some time, leaving there to work in Decatur, Illinois. He left Decatur in September, 1882, to accept the position of Roundhouse Foreman at Bellevue, Ohio, on the New York, Chicago & St. Louis Railroad, which had just been opened for traffic at that time. He held this position for two years, resigning it to become Engine Despatcher of the New York & New England Railroad at Hartford, Connecticut, remaining in this position until 1886, when he went to Louisville as Engine Despatcher of the Louisville, New Albany & Chicago Railroad. He accepted the position of Engine Despatcher at Cleveland on the Erie Railroad in January, 1887, and was promoted to Master Mechanic of the Mahoning Division of the Erie Railroad, with headquarters at Cleveland, July 1, 1887, remaining in this position until he resigned August 15, 1894.

From the latter date until his death he was employed as foreman of the Brown Hoist and Conveyor Company, of Cleveland.

While returning home from work April 11, 1900, he attempted to board a Superior Street cable car while it was in motion and was thrown under the car and so badly injured that he died April 14, 1900. The interment was made in Woodland Cemetery, Cleveland, April 17, 1900.

In October, 1890, Mr. Carmody was married to Miss Annette Ashall, who survives him.

Mr. Carmody was a thorough mechanic and was very popular with the employes.

WILLARD KELLS.

JAMES CULLEN.

Mr. James Cullen was born in the County of Wexford, Ireland, February 4, 1836, and died at Nashville, Tennessee, April 19, 1900.

At the age of thirteen he came to America and located at Detroit, Michigan, where he attended school about four years, after which he served an apprenticeship with the Detroit Machine & Locomotive Works. He went to Lafayette, Indiana, in 1857, where he worked as machinist in the shops of the Lafayette & Indianapolis Railroad, after which he filled the following positions successively: Foreman in the shops of the Little Miami Railroad, at Columbus, Ohio; foreman in the shops of the Marietta & Cincinnati Railroad, at Lima, Ohio; foreman in the United States Government shops, at Stephenson, Ala.; foreman in the shops of the Alabama & Tennessee Railroad (afterward known as the Selma, Rome & Dalton Railroad), at Selma, Ala.; journeyman and engineer for the Nashville & Chattanooga Railroad, at Nashville, Tenn.; foreman of the machine shop and roundhouse of the St. Louis & Southwestern Railway, at Edgefield, Tenn.

He went back to Lafayette, Ind., in 1874, and worked as a journeyman in the shops of the Lafayette & Indianapolis Railroad, but returned to Nashville the same year as Master Mechanic of the Nashville & Chattanooga Railway (afterward the Nashville, Chattanooga & St. Louis Railway), and several years later he was appointed Superintendent of Machinery of the same road, which position he filled until his death.

He was a sufferer from Bright's disease for about two years and consulted many eminent physicians, but was unable to restrain the disease which finally caused his death.

A widow and four children, two boys and two girls, survive him.

The life and career of Mr. Cullen give a striking example of the force of inherent native qualities. Never having had the advantages of the liberal education so easily acquired at the present day, either in lines that would insure the polished orator, or classical scholar; nor that technical education which smooths the pathway of the executive officer in mechanical departments of life, and (let it be said) though somewhat brusque in manner and, in public, somewhat lacking in the graces of the tongue, still, so full was he of native grace and kindness that there are but few men who have been so universally accorded to have exemplified to the fullest, the attributes of a true gentleman. He was a "manly man"; of clear convictions, fearless candor and complete justice; one whose friendship, once obtained, proved an account on which his friends could always draw without fear that it had been overdrawn or even taxed. To the best knowledge and belief of this writer there was never one who knew him intimately who will not join in saying that it seemed impossible that James Cullen could entertain an impulse or an impression that was not true to his high sense of duty to his family, himself, his friends, his employers, his employes and his God. As a mechanic, entering the railroad service at a time when the sources of technical knowledge were not so great as at present, nor the demand for it so imperative, he yet kept progress with the times to such an extent that, while he was somewhat diffident in expressing himself on the floor at conventions, yet he was so fertile in information and resources that it was a pleasure and a profit to converse with him on such topics as were germane to the occasions and most intimately connected with the science of railroading as it continually developed into practical results.

As an executive officer his sense of responsibility, to both employer and employe, was so keen that, on the day of his death, those who had been associated with him for years as employes, gave vent to such expressions of grief at their own loss and such eulogies of their friend who was now gone before, as renders all attempt to describe it idle. If the sense and sincerity of those expressions could be condensed into an epitaph, it would be the most elegant and expressive composition ever written. In direct connection with this demonstration of loyalty and love by those over whom he had direct official supervision, there was offered an ovation that clearly proves that the characteristics which had endeared him to his men were compatible with an equal loyalty to his employers, and were as fully appreciated by them. This was evidenced by a mark of respect, never to my knowledge previously paid to any man in our walk of life. As his body passed the cemetery gates every train on the system of railroad with which he was connected, by order of the President, came to a full stop for five minutes. With a record so clear, a life so well lived, a death so surrounded by affectionate remembrance and a future so well assured, we can only bow our heads in mute submission, while we so fully realize "It is only those who are left who suffer."

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INDEX.

A

Address of President, 33-36.
" " welcome, A. T. Pitkin, 31-33.
Adoption of minutes of last meeting, 37.
Alphabetical index of reports, papers and discussions, Vols. I-XXXII, 68-75.
Annual dues, announcement of, 46.
Appointment of committees on obituaries, 66.
Associate member, F. W. Lane, proposed, 47.
Auditing committee, election of, 46, 47 ; report of, 160.
Axles for heavy tenders, standard, 377.

B

Battye, J. E., obituary of, 382.
Bearings, journal, use of nickel steel; topical discussion, 62-66.
Boilers, stationary, best form for shop purposes; report of committee on, 339-348 ; discussion on, 349-351.
Boiler, steel specifications, standard, 378.
" tubes, specifications and tests for, standard, 378-380.
Bolt heads, size of, standard, 372.
" " square, standard, 381.
By-Laws and Constitution, 7-12.

C

Cabs, metal *vs.* wooden, topical discussion, 258-260.
Carmody, T., obituary, 386.
Cast-iron and steel-tired wheels, relative merits of, report of committee on, 109-110 ; discussion, 110-112.
Classified index, reports and papers discussed, Vols. I-XXXII, 76-94.
Committee, auditing, election of, 467.
Committee on :
  Auditing, report of, 160.
  Best type of stationary boilers for shop purposes, report of, 339-348 ; discussion, 349-351.
  Changes in Constitution, appointment of, 59.
  Compound locomotives, report of, 160-227 ; discussion, 227-249.
  Correspondence and resolutions, report of, 365.
  Extent to which the recommendations of the Association have been put into practice, report of the, 67-107; discussion, 107-109.
  Flanged tires, report on, 133-150 ; discussion, 151-160.
  Journal bearings, cylinder metals and lubrication, report of, 267-300 ; discussion, 307-311.

Piston valves, report of, 306, 307 ; discussion, 307-311.
Power transmission, shafting *vs.* electricity, report of, 311-328 ; discussion, 328-339.
Preparation of index, proposed, 59.
Relative merits of cast-iron and steel-tired wheels, 109, 110; discussion, 110-112.
Revision of Constitution and By-Laws, report of, 261-263.
Subjects, report of, 364, 365.
Ton-mile statistics, report of, 112-121 ; discussion, 121-130.
What can the Association do to increase its usefulness, report of, 52-58 ; discussion, 58-62.

Committees and subjects, 5, 6.
Communications — National Railway Blacksmiths' Association, 50.
Compound locomotives, report of committee on, 160-227 ; discussion, 227-249.
Constitution and By-Laws, 7-12.
" appointment of committee on changes in, 59.
Contributions to printing fund, 389-391.
Correspondence and resolutions, report of committee, 365.
Cullen, James, obituary, 387.
Cylinder metals, report of committee on, 267-300.

D

Discussion of reports on :
Best type of stationary boiler for shop purposes, 349-351.
Compound locomotives, 227-249
Extent to which the recommendations of the Association have been put into practice, 107-109.
Flanged tires, 151-160.
Journal bearings, cylinder metals and lubrication, 300-305.
Piston valves, 307-311.
Power transmission by shafting *vs.* electricity, 328-339.
Relative merits of steel-tired and cast-iron wheels, 110-112.
Revision of Constitution and By-Laws, 263-266.
Ton-mile statistics, 121-130.
What can the Association do to increase its usefulness, 58-62.

Discussion of topical subjects :
Graphite as a lubricant, 361-363.
Limit of length of 2-inch tubes, 249-258.
Metal *vs.* wooden cabs for locomotives, 258-260.
Nickel steel as a journal bearing, 62-66.
Pooling of locomotives, 351-360.

Driving-wheel centers, standard, 375.
Dues, annual, announcement of, 46.
" collected, details of, 39-45.

E

Election of auditing committee, 46, 47.
" " F. B. Miles, honorary member, 260.
" " officers, 366-370.
Electric *vs.* shafting power transmission, report of committee on, 311-328; discussion, 328-339.
Executive Committee, report on honorary membership of F. B. Miles, 260; report on general subject of honorary membership, 261.
Extent to which the recommendations of the Association have been put into practice, report on, 67-107.

F

Flanged tires, report of committee on, 133-150; discussion, 151-160.
Flues, limit of length, topical discussion, 249-258.
Friday's session, 132-266.

G

Gauge, decimal, standard, 373.
" sheet-metal, standard, 373.
Gauges, limit, for round iron, standard, 374.
Glover, J. B., Jr., obituary, 382.
Graphite as a lubricant, topical discussion, 361-363.

H

Harrison, W. H., obituary, 383.
Honorary member, F. B. Miles, proposed by Executive Committee, 50.
" members proposed, 47; referred to Executive Committee, 49.

I

Index, alphabetical and classified, subjects, reports and discussions, Vols. I-XXXII, 68-94.
Index of Proceedings, appointment of committee on, 59.
International Association for Testing Materials, proposition to join, 62.
Invitations — Schenectady Locomotive Works, 36, 37.

J

Journal bearings, report of committee, 267-300.

L

Lane, F. W., proposed as Associate member, 47.
Lubrication, report of committee on, 267-300.

M

McConnell, J. H., address of, 33-36.
Members, list of, 13-28.
  " present, 29, 30.
Miles, F. B., proposed as honorary member, 50; elected, 260.
Methods of conducting boiler tests, standard, 378.

N

Names and addresses of members, 13-28.
Nickel steel as a journal bearing, topical discussion, 62-66.
Noon-hour discussions:
  Graphite as a lubricant, 361-363.
  Limit of length of 2-inch tubes, 249-258.
  Metal *vs.* wooden cabs, 258-260.
  Nickel steel as a journal bearing, 62-66.
  Pooling of locomotives, 351-360.
Nuts, sizes of, standard, 372.

O

Obituaries, appointment of committees on, 66.
  " 382-388.

P

Pipe thread, standard, 380.
Piston valves, report of committee on, 306, 307; discussion, 307-311.
Pitkin, A. J., address of welcome, 31-33.
Player, John (Dunkirk, N. Y.), proposed as associate member, 267.
Pooling of locomotives, topical discussion, 351-360.
Power transmission, shafting *vs.* electricity, report on, 311-318; discussion, 328-339.
President's address, 33-36.
Printing fund, 389-391.

R

Reports of committees on:
  Auditing, 160.
  Best type of stationary boilers for shop purposes, 339-348. Questions submitted, 339-341; return tubular boilers, 341; water tube boilers, 341-344; locomotive type, 344; generation and use of superheated steam, 344; grates, 345; fuel, 345; tubes, 345; ratio of grate area to heating surface, 346; evaporation with different types of boilers, 346; conclusions, 347; discussion, 348-351.
  Compound locomotives, 160-227. Subjects treated: Duties of committee, 160, 161; reduction of waste steam effected by compound-

ing, 161; complications, 161; advantages, 161; disadvantages, 161; early efforts, 162; development, 162; yearly product, 163; reports of committee, 164; opinions of committee, 165; summary of discussions, 166; relative performance, compound *vs.* simple engines, 167; circular of inquiry and answers, 168-175; conclusions of committee, 175-177; description of starting mechanisms of various makes; Baldwin-Vauclain, 178-180; Baldwin two-cylinder, 180-184; Brooks tandem, 184-186; Brooks two-cylinder, 186, 187; Cook two-cylinder, 187, 188; Richmond cross compound, 188-191; Schenectady two-cylinder, 191-195; answers to circular of inquiry, 196; performance of Richmond compound, 219; reference to literature, 219-227; discussion on, 227-249; conclusion No. 1 ordered omitted from report, 241.

Extent to which the recommendations of the Association have been put into practice, 67-107. Alphabetical and classified index of reports, papers and discussions thereon, 68-94; details of replies as to the use of standards, 96-107; discussion, 107-109.

Flanged tires, 133-150. Subjects treated: Conditions of tests, dynamometer and hydrokinetic, 133, 134; kind and location of tires, 134; description of dynamometer, 134; description of tests, 134; description of hydrokinetimeter, 135; results of tests, 135; records of tests, 137-150; discussions on, 151-160.

Journal bearings, cylinder metals and lubrication, 267-300; deductions of committee, 267-271. Subjects treated: Cylinder metal mixtures, 271; cylinder saddles and cylinder separate, 276; breakage of cylinder saddles cast in pairs, 281; use of solid piston heads, 281; cylinder wear, 281, 282; piston head and packing ring metal mixtures, 282, 283; diameters of piston heads, 283; diameters of packing rings, 284; bearing metal alloys, 284; use of soft metals, 286; purchase of bearing metals, 287; lubrication, 289, 290; use of modern lubricators, 290; location of oil-holes, grooves and pockets in driving boxes, 290-300; discussion of, 300-305.

Piston valves, 306, 307; discussion, 307-311.

Power transmission on shafting *vs.* electricity, 311-328. General headings for comparison, 312; efficiency separate power plants, 312; efficiency central power plants, 312; attendance, 313; repairs, 313; interest, 313; restrictions of steam power plants, 313; electrical transmission not restricted, 314; special appliances, 314; flexibility, 314; speed control, 314; efficiency electrical transmission plants, 315; efficiency steam power plants, 315; systems applicable for installation, 317; voltage, 318; generators, type and size, 318; rating of, 318; motors, types of, 319; tool driving, 321; conclusions, 321; electric transmission systems, 322; generators, description of, 322; wire, distributing system, 324; motors, 324; examples of electric shop power plants: Westinghouse Air Brake Co., 325, 326; General Electric Co., 326, 327; Baldwin Locomotive Works, 327, 328; discussion on, 328-339.

Relative merits of cast-iron and steel-tired wheels, 109, 110; discussion, 110-112.
Resolutions and correspondence, 365.
Revision of constitution and by-laws, 261-263; discussion, 263-266.
" " " proposed, 261-263.
Subjects, 364, 365.
Ton-mile statistics, 112-121. Items considered: Use of ton-mile basis, 114; comparison of statistics, 114; tonnage included, 115; service included, 115; most accurate basis for all service, 117; difference between ton-mileage and ton-rating, 117; statistics should represent total work done for money spent, 117; should include weight of train, 118; different departments each to have proper basis for statistics, 119; expense of comparing statistics, 120; conclusions, 120; recommendations, 120, 121; discussion, 121-130.
What can the Association do to increase its usefulness? 52-58; discussion, 58-62. Subjects recommended: Appointment of nominating committee, 52; letter ballot for associate members, 52; record votes on questions of practice, 52; prearranged discussion of reports, 53; selection of committees, 53; individual papers, 53; reading papers by abstract, 54; discussion of subjects before clubs, 53; instructions to committees, 54; subjects for investigation, 55; selection of committees, 55; topical discussions, 55; index to reports, 56; character of reports, 56; use of heavy-face type for conclusions of committees, 56; library, 57; conclusions and recommendations, 58.
Report of Executive Committee on honorary membership: F. B. Miles, 260; on general question of honorary membership, 261.
Report of Secretary, 38-45.
" Treasurer, 46.
Resolutions and correspondence, report of committee on, 365.

S

Saturday's session, 267-370.
Scholarships, Stevens Institute of Technology, 45.
Screw threads, standard, 371.
Secretary's report, 38-45.
Shafting *vs.* electricity, transmission of power, report of committee, 311-328.
Standards of the Association:
  Axles for tenders, 377.
  Boiler steel specifications, 378.
  Decimal gauge, 373.
  Driving wheel centers, 375.
  Form of tires, 376.
  Limit gauges for round iron, 374.
  Methods of conducting locomotive tests, 378.
  Pipe threads, 380.

Screw threads, 371.
Sheet metal gauge, 373.
Sizes of nuts and bolt heads, 372.
Sizes of tires, 375.
Specifications and tests for boiler tubes, 378-380.
Square bolt heads, 381.
Stationary boilers, best type for shop purposes, report of committee on, 339-348 ; discussion, 349-351.
Stearns, W. H., obituary, 385.
Steel boiler specifications, standard, 378.
Steel-tired and cast-iron wheels, relative merits of, report of committee on, 109, 110 ; discussion, 110-112.
Subjects and committees, 5, 6.
Subjects, report of committee, 364, 365.

T

Thursday's session, 29-131.
Tires, form of, standard, 375.
" sizes of, standard, 375.
Tomlinson, J. G., obituary, 385.
Ton-mile statistics, report of committee on, 112-121 ; discussion on, 121-130.
Topical discussions :
Graphite as a lubricant, 361-363.
How to make pooling of locomotives a success, 351-360.
Limit of length of 2-inch flues, 249-258.
Metal *vs.* wooden cabs, 258-260.
Nickel steel as a journal bearing, 62-66.
Treasurer's report, 46.
Tubes, boiler, limit of length, topical discussion, 249-258.
" " specifications and tests of, 378-380.

V

Valves, piston, report of committee on, 306, 307 ; discussion, 307-311.

W

Wheels, steel-tired and cast-iron, relative merits of, report of committee on 109, 110 ; discussion, 110-112.

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